DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY.

GEOLOGICAL and MINERALOGICAL SURVEY.

FIRST REPORT OF PROGRESS.

E. T. DUMBLE,
STATE GEOLOGIST.

1888.

AUSTIN:
STATE PRINTING OFFICE.
1889.

LETTER OF TRANSMITTAL.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS AND HISTORY,
AUSTIN, TEXAS, December 31, 1888.

To His Excellency L. S. Ross, Governor of Texas:

DEAR SIR—By act of the special session of the Twentieth Legislature, this department was required to have made a geological and mineralogical survey of Texas, empowering the Commissioner with full authority to employ the agents and incur the expenses necessary to execute said law, and appropriating fifteen thousand dollars therefor. The method of organization, plan of work, and all details of the survey were left entirely to the discretion of the Commissioner. The additional responsibility thus placed upon this department was for a time the cause of much apprehension and fear lest I should be unable to secure such agents and effect such an organization of this branch of the office as would inspire public confidence, receive the co-operation of the people, and insure the successful prosecution of the work.

I first adopted a plan of organization, which, briefly stated, was to appoint a chief geologist with power to select his assistants and manage all details of the survey. This much having been done, the delicate and difficult task of selecting a competent person for the position of State Geologist was yet to be performed. There were many applicants for the place, both from within and without the state, the majority of whom were, no doubt, competent geologists. After a patient investigation of the qualifications and claims of each, the appointment was tendered to Mr. E. T. Dumble, of Houston, who accepted the position and entered upon the discharge of his duties September, 21. Mr. Dumble brings to bear in the performance of his duties a ripe scholarship, and several years experience as a geologist acquired on Texas soil in prosecuting investigations for private parties and as secretary of the State Geological Society. I do not feel that I am stating a fact too strongly when I say that Mr. Dumble already possesses a more thorough and scientific knowledge of the geology of Texas than could be acquired by any new man by close application and hard study for several years. All true Texans must feel a commendable state pride in the fact that we have such a man among us, and will rejoice when an opportunity is offered to do him honor.

As to the character and value of the work so far accomplished but little need be said. In the very nature of things in a state of the magnitude of Texas, it was impossible to have done much more than inaugurate the survey in so short a time, but enough has been done to demonstrate the wisdom of the legislature in providing for a geological survey of the state, and to justify appropriations sufficient for its continuation.

For this purpose, and to carry out plans already devised which are deemed essential to the successful prosecution of the work of the survey, an appropriation of $35,000 per annum is respectfully recommended.

The expenditures of this branch of the office up to December 15, 1888, amounted to $3,983.71, divided as follows:

Salaries state and assistant geologists	$1,348 87
Salaries of state chemists	164 88
Salaries of clerks	664 00
Equipments	997 12
Field expenses	785 85
Offices expenses	22 99
Total	$3,983 71

Vouchers for all items constituting the above named sums are on file in this office.

The following are the

PLANS OF THE SURVEY

as outlined in circular number two of the State Geologist:

1st. A search for ores, minerals, oils, coals, clays, and other minerals possessing a commercial value, and the determination of the question, whenever possible, whether they exist in sufficient quantities and under suitable conditions and surroundings to make it reasonably certain that it will be profitable to work them.

2nd. An investigation of the geologic formation and the topography of the country with a view to determining the probability of obtaining artesian water and the feasibility of irrigating from such wells as well as from streams, shallow wells, or tanks, where necessary.

3rd. The determination of the adaptability of soils to certain crops, and how their fertility can be increased by the use of materials nearest at hand.

4th. The search for and development of useful articles as yet not fully known.

These will be closely adhered to, and detailed surveys of each district by counties will be commenced at the earliest practicable moment, the result of which will be published in bulletins as rapidly as each county is completed.

REQUISITES.

The enactment of a mining law such as will really encourage prospecting for the various minerals in the districts described and pointed out by the survey.

Appropriations sufficient to carry on the work in a proper manner, taking into consideration the area of the state and the needs of each portion of it.

Very respectfully,

Your obedient servant,

L. L. FOSTER,

Commissioner Agriculture, Insurance, Statistics, and History.

Hon. L. L. Foster, Commissioner of Agriculture, Insurance, Statistics, and History:

SIR—I have the honor to transmit herewith my report of the progress of the Geological and Mineralogical Survey of Texas for the first two months of its existence.

The short time which has elapsed since the organization of the survey prevents a detailed report on any particular section. Such reports will be issued as bulletins as rapidly as they can be completed.

Yours, very respectfully,

E. T. DUMBLE,
State Geologist.

AUSTIN, TEXAS, December 18, 1888.

GEOLOGICAL AND MINERALOGICAL SURVEY OF TEXAS.

FIRST REPORT OF PROGRESS.

DECEMBER, 1888.

Receiving my appointment as State Geologist September 21st, I proceeded at once to the organization of the survey.

Taking into consideration the area of the state and the varied character of its geology and mineral deposits, it was deemed best to divide the state into districts, with a surveying party in each. Accordingly, Professor W. H. Streeruwitz was appointed Geologist for Western Texas, Professor W. F. Cummins, Geologist for Northern Texas, and Dr. R. A. F. Penrose, Jr., Geologist for Eastern Texas.

There being no room in the Capitol building which could possibly be used as a chemical laboratory without serious inconvenience to all who might have offices in its neighborhood, and very favorable conditions being offered by Professor Everhart, of the University of Texas, and Professor Harrington, of the Agricultural and Mechanical College, it was decided best to have the chemical work done at those institutions. The chemical department was then organized by the appointment of Mr. J. H. Herndon chemist, with Mr. Matt. M. Smith and R. B. Halley as assistants, at the University laboratory. The appointment of chemist at the laboratory of the A. and M. College will be made January 1st. In order that those desiring analyses made might be apprised of what was necessary, the following circular was issued:

GEOLOGICAL SURVEY OF TEXAS.

Circular No. 1.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY,
AUSTIN, TEXAS, October 1, 1888.

The law directing the Commissioner of Agriculture, Insurance, Statistics, and History to have a geological and mineralogical survey made of the State of Texas, makes it also his duty, "upon the request of any person, to require assays or analyses of any specimen of soil or mineral deposit in this state, and to furnish to the party requesting it a certificate thereof; *provided*, that in all cases when assays or analyses are made upon request of any person, the party making the request shall be required by the commissioner to make affidavit that the specimen offered was found upon the land of the party making the request, or that said request is made at the instance or with the full knowledge and consent of the owner of the land upon which said specimen was found."

In compliance with this requirement, the laboratory of the survey is now open, and fully prepared to make analyses of any specimens of soils, ores, minerals, or mineral waters, which may be sent in under the provisions of this act.

The schedule of fees which has been adopted is intended to cover only the probable amount of chemicals and apparatus used in making the analysis, without taking into any account the time and labor involved. This has been done in order that every one who has any ore, clay, coal, or other mineral substance, may ascertain its true value at the lowest possible cost, to encourage the search for minerals by the owners of land, and especially to induce the farmer to become more thoroughly acquainted with the true nature of his soil.

DIRECTIONS FOR SENDING SPECIMENS.

All packages sent must be marked with the name of the sender, in addition to the ordinary direction, and a letter of advice must be sent by mail with each shipment, enclosing a list of samples forwarded, the necessary affidavit, and a remittance covering the probable amount of charges for analysis, according to schedule of fees given below.

Ores and Minerals.

In sending ores and minerals any amount from two to eight ounces of each will be sufficient for analysis. Each sample should be carefully wrapped in strong paper and numbered (if there are more than one). These may then be either sewed in cloth, if perfectly firm and not liable to become powdered in transit, or sent in a light box, packed tightly with paper, cotton, or other packing material, and forwarded by mail or express, freight prepaid.

Coals

should be sent in somewhat larger quantities, from one-half to two pounds, as may be convenient, and preferably boxed.

Mineral Waters.

Take a five-gallon jug, wash and rinse it perfectly clean, and fill it directly from the spring or well, sending only the clear water, without sediment. Cork tightly and seal it securely. It is best to ship by express, prepaying charges. If an analysis is wanted of the sediment it may be collected in sufficient quantity and forwarded at the same time.

Directions for Taking Soil Specimens.

First. Do not take samples indiscriminately from any locality, but consider what are the two or three chief varieties of soil which, with their intermixtures, make up the cultivable area of your region, and carefully sample these first of all.

Second. As a rule, and whenever possible, take specimens only from spots that have not been cultivated or otherwise changed from their original condition of "virgin soil;" that is, not from ground frequently trodden over, such as roadsides, cattle-paths, small pastures, or squirrel holes and stumps, or even the foot of trees, or spots that have been washed by rains or streams, so as to have undergone a noticeable change, and therefore not be a fair representative of the general soil.

Third. Observe and record carefully the normal vegetation, trees, herbs, grass, etc., of the average land. Avoid spots showing unusual growth, whether in kind or quality, such as are likely to have received some animal manure or other outside addition.

Fourth. Always take specimens from more than one spot judged to be a fair representative of the soil intended to be examined, as an additional guarantee of a fair average.

Fifth. After selecting a proper spot, pull up the plants growing on it, and scrape off the surface lightly with a sharp tool, to remove half decayed vegetable matter not forming part of the soil as yet. Dig a vertical hole, like a post hole, at least twenty inches deep; scrape the sides clean, so as to see at what depth the change of color or tint occurs which marks the downward limit of the surface soil, and make a note of it; take at least half a bushel of the earth above this limit, and, in a cloth or paper, break it up and mix thoroughly, and put up at least a quart of it in a sack or package, marking the package plainly. This specimen will ordinarily constitute the "soil." Should the change of color occur at a less depth than six inches, the fact should be noted, but the specimen taken at that depth nevertheless, since it is the least to which rational culture can be supposed to reach. In case the difference in the character of a shallow surface soil and its subsoil should be unusually great, as may be the case in tule or other alluvial lands, or in rocky districts, a separate sample of that surface soil should be taken, besides the one to the depth of six inches.

Specimens of salty, or "alkali," soils should, as a rule, be taken only toward the end of the dry season, when they will contain the maximum amount of the injurious ingredients which it may be necessary to neutralize.

Sixth. Whatever lies beneath the line of change, or below the minimum depth of six inches, will constitute the subsoil; but should the change of color occur at a greater depth than twelve inches, the soil specimen should nevertheless be taken to a depth of twelve inches only, which is the limit of ordinary tillage; then another specimen from that depth down to the line of change, and then the subsoil specimen beneath that line. The depth down to which the latter should be taken will depend on circumstances. It is always desirable to know what constitutes the foundation of a soil down to a depth of three feet at least, since the questions of drainage, resistance to drought, etc., will depend essentially upon the nature of the substratum; but in ordinary cases ten or twelve inches of subsoil will be sufficient for the purposes of examination in the laboratory. The specimen should be

taken in other respects precisely like that of the surface soil, while that of the material underlying this subsoil may be taken with less exactness, perhaps at some ditch or other easily accessible point, and should not be broken up like the other specimens.

Seventh. All peculiarities of the soil and subsoil, their behavior in wet and dry seasons, their location, position—every circumstance and fact that can throw any light on their agricultural qualities or peculiarities—should be carefully noted, and the notes sent with the specimens.

FEES FOR ANALYSIS.

For analysis of any ore, coal, or mineral, where not more than four determinations are to be made	$2 00
Each additional substance determined	50
(A coal or mineral containing copper, silver and gold, or lead and silver or iron, sand, phosphorus and sulphur, would fall within the first rate.)	
For analysis of any soil when general character alone is wanted	5 00
If special examination is required a price will be fixed on application.	
For analysis of mineral water	$10 00

E. T. DUMBLE, State Geologist.

This circular was mailed to all newspapers in the State so far as we could get the addresses, to the members of the legislature, district and county judges, and many private citizens.

Having thus completed the organization of the survey, the following circular was issued:

GEOLOGICAL SURVEY OF TEXAS.

Circular No. 2.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY,
AUSTIN, TEXAS, October 11, 1888.

The plan of operations adopted for the Geological Survey of Texas divides the State temporarily into four districts, with a surveying corps in each; and as their work is intended solely to develop the resources of the state, the co-operation and assistance of the people is most earnestly solicited. To this end we desire to secure reliable correspondents and observers in every county, from whom information may be obtained which will greatly facilitate the work of the geologists by enabling the State Geologist to direct the surveying parties to the greatest advantage. These surveying parties can only examine a limited area each season, and the immense extent of the state will render it very difficult to accomplish the work desired without the active co-operation and assistance asked for on the part of the people most interested.

The work will be particularly directed; first, to a search for ores, minerals, oils, coals, clays, and other materials possessing a commercial value, and the determination of the question, whenever possible, whether they exist in sufficient quantities and under suitable conditions and surroundings to make it reasonably certain that it will be profitable to work them; second, to an investigation of the geologic formation and topography of the country with a view to determining the probability of obtaining artesian water, and the feasibility of irrigating from such wells, or from streams, shallow wells, or tanks, where necessary; third, to the determination of the adaptability of soils to certain crops, and how their fertility can be increased by the use of materials nearest at hand; and fourth, to the search for and development of useful articles as yet not fully known.

The collection of fossils and study of geologic strata, though a necessary concomitant, will be made (as far as is consistent with obtaining a correct knowledge of their character and influences) subordinate and subsidiary to the economic features of the survey.

Trusting that the plan thus briefly delineated will meet your hearty approval, the State Geologist asks your aid, believing that with the assistance asked for the Geological Survey can and will be made a complete financial and scientific success.

E. T. DUMBLE, State Geologist.

This circular was also mailed to all members of the legislature, and to county and district judges; it was also forwarded to all the newspapers of the state, the greater number of which kindly published it. This was done in order that the people might understand the general plan of the Survey, and that by arousing their interest in its success we would be able to secure their help.

That it met with popular approval is attested by the results. Replies began to come in at once and much information of real value was obtained. In order that this might be made most available, I prepared the following circular, of which copies were sent to every county in the state:

GEOLOGICAL SURVEY OF TEXAS.

Circular No. 3.

DEPARTMENT OF AGRICULTURE, INSURANCE, STATISTICS, AND HISTORY,
AUSTIN, TEXAS, November, 1, 1888.

DEAR SIR—Enclosed you will find a map of your county, and a list of the Economic Minerals reported to be found in Texas. Those marked * are either reported from, or supposed to exist in your county. We wish to obtain all the information we can concerning them, and respectfully ask that you will furnish such information as you may be able as indicated by the following requests and queries:

You will notice that in the list of minerals each item is preceded by a number. Please designate the locality in your county where any mineral has been found, by writing its number on the map at the place where found. If you wish to distinguish between two or more locations for any special purpose, such as different qualities of the same mineral, etc., add small letters to the number thus: 2*a*, 2*b*, 2*c*, etc.

TOPOGRAPHY.

If the streams and ravines laid down on the map are incorrect in any way, please make correction in red ink.

Are any of these streams or ravines so situated that by constructing suitable dams the water generally running off during heavy floods could be retained and used for irrigation? If so, please note possible localities.

Mark, if practicable, the location of any prominent hills or mountains, bluffs along the streams, and especially the course of any ranges of hills. If you have any record of the correct elevation of different points above the sea level, please give them.

GEOLOGY.

If you have made any personal observations on the different formations occurring in your county, or have access to the notes of others who have done so, please give us such information as you can regarding this subject, including boundaries of the different formations, stratigraphy, character of rocks, dip, strata, sections wherever it is possible to obtain them, and such fossils as may have been recognized.

What is the extent of beds of boulders, gravel, and sand in your county? If hilly, state on which side of hills you find the heaviest deposits.

What is the character of water found by digging? Through what kind of strata do the wells penetrate, and in what kind of bed is the water found? What efforts have been made to secure artesian water? What success? Was any record kept of the borings, which you can obtain for us?

What effort has been made to irrigate, and with what result?

What are the generally characteristic soils of the county? Are there any soils of exceptional fertility or of marked sterility? If so, please state location and extent, and send such specimens of each as you can obtain.

What alkali soils, if any, are found?

What stone suitable for building is found in your county? Please describe, giving locality and quantity, and also the number and location of quarries if any.

What limestone is there suitable for lime making? Are there any kilns in regular operation?

Is there any rock suitable for making hydraulic cement? Has it been used to any extent?

What sand deposits have you suitable for mortar and plaster?

Have you brick clays of good quality? Do they burn red, yellow, or white?

What fire clays have been found? To what extent have they been tested?

Do you find any potter's clay, kaolin, or (as it is sometimes called in Eastern Texas) chalk? Has any of it been mined and shipped to manufactories? Are there any factories in your county engaged in making pottery, sewer pipe, etc.?

Are there any bat caves or deposits of bat guano? If so, has the guano been used or shipped?

If copper exists, please state the manner of its occurrence, as well as locality, whether it is in loose pieces or embedded in rock.

Coal—(including lignite or brown coal). Please state method of occurrence as well as locality. If shafts have been sunk to it, or it has been found in digging wells, a record of the strata passed through, giving character and thickness of overlying clay, rock, etc., will be of value. If more than one seam is found, please state it; and if the seam is divided by clay, shale, slate, etc., please state the thickness of the upper and lower coal, as well as that of the dividing material.

If millstone grit occurs, please state what use has been made of it, or what effort has been made to develop it.

What whetstone material do you find?

Gypsum.—In addition to the large deposits of North Texas, this mineral is disseminated over a large portion of the state, and appears in a crystalline form along the banks of many of our streams, and is often known as "mica." Please state especially the quantity, if you have any. Is it being used in any way?

The green sand marls of the cretaceous and tertiary formations will prove very valuable as fertilizers in the near future. It is desirable that their location and extent be defined as closely as possible. In this connection, please state locality of any bone beds, if such are known to exist.

Iron.—Ores of this metal are widely distributed over the state, and are of as great diversity of character as of location, varying all the way from a sandstone impregnated with iron to some of the finest grades known. We wish to know locality, mode of occurrence, and quantity of these deposits.

Lead.—Ores are found in several counties, and are frequently silver bearing. Float ore is also frequently found in sections where it would not be expected.

Where petroleum, asphaltum, or natural gas is known to exist, or its existence is suspected, please state all known facts bearing on it.

Salt—Salt Beds, Lakes or Wells.—Please give location and description of these, and also state to what extent they have been or are being worked.

What mineral waters are there, and how do they occur.

In general, please state such facts as you may have concerning all other mineral products you are acquainted with in your county, giving us actual occurrences only, or if from report, so state it.

SPECIMENS.

We wish specimens of soils, building stones, and all minerals, as far as we can obtain them.

Specimens of soils should be taken in the manner described in Circular No. 1. Specimens of building stone should be large enough to permit a 4-inch cube to be cut from it. Other specimens should be $2 \times 4 \times 6$ inches, if possible. Each specimen should be carefully wrapped in strong paper, with a number or label by which it can be identified. All specimens sent should be securely boxed to prevent crushing.

REPORT.

Please mail report to State Geologist, on or before December 1, shipping specimens by rail at same time, according to instructions given in Circular No. 1, except prepayment of freight.

E. T. DUMBLE,
State Geologist.

The information and specimens obtained by this method are very valuable, and the aid which they will afford in the future conduct of the survey almost incalculable. The best results, however, which these circulars accomplished was not alone the accurate information obtained of localities, although this would have taken many months to ascertain by means of the few parties engaged in the survey, nor the aid which the knowledge thus gained will be in the shaping of the future work of the field parties, while this, too, is extremely important; but in the visible proof given by the prompt and intelligent answers to questions, and the requests for parties to make investigations, that the people of every section of the state are not only fully alive to the importance of the work before us, but ready and willing to do all in their power to aid in its success. And it may here be remarked that of a certainty there is not one county in Texas which will not be directly benefited by the work of the Geological Survey if carried out in accordance with the plans now under consideration.

OFFICE WORK.

The work done in the office comprises the preparation of maps and tracings of profiles, the classification of the results of previous investigations both by the state and many private observers, with the addition of the information received in response to circulars, a very extensive correspondence with observers and many parties desiring information on particular subjects connected with the survey, the arrangement, study, and labelling of specimens received from the various surveying parties, together with the compiling of their reports and preparing them for the printer.

This work in itself has been of such volume that I have been able to do very little field work, which, however, if attempted, would have been materially interfered with by the continued rains of November.

TOPOGRAPHIC WORK.

The first necessity for correct geologic work is an accurate topographic map of the district to be examined, and as no work of this character has ever been done by the state, the survey will be somewhat hampered in its operations by lack of this important requisite. To obviate this in some degree we have asked from the different railroads of the state tracings of the profiles and grade lines of their roads. Many have already responded, and we hope to have, before long, all of the information obtainable from this source.

The only actual topograhic work which has been done is that under the direction of the United States Geological Survey, which has had three parties of surveyors in this state for the past four years. The area for which we now have these topographic maps comprises some 19,000 square miles, lying between longitude 97° and 99° 30′, and latitude 32° 30′ and 30°. These maps are on a scale of two miles to one inch, with contour intervals of fifty feet, and the survey is being carried on at the rate of 4000 square miles or more per year. This rate of survey is not rapid enough to give us the assistance we need in the prosecution of the geologic work, and I have therefore written Major J. W. Powell, Director of the U. S. Geological Survey, placing the matter before him, and requesting that he increase the topographic force in this state by putting a corps of engineers in the Trans-Pecos region during the present season. In reply he writes, assuring this survey of his desire to co-operate with us in any way in his power, and states that he hopes to be able to put parties into the district requested during the present winter, but that he may be prevented from doing so by demands made upon the survey in the interests of irrigation. It is of the highest importance to the state that this work should be done at once, if we are to proceed promptly and satisfactorily with our in estigations.

METEOROLOGICAL WORK.

The importance of an exact knowledge of the rainfall of every section of the state is apparent to all, and is fully stated in the discussion of the subject of artesian water. Other meteorological conditions are of equal importance, and in order that such knowledge may be obtained the survey has secured the co-operation of the State Weather Bureau, organized in accordance with the regulations of the United States Signal Service, and we are now establishing stations in sections where none have previously existed. In order that these records should possess their full value, it is necessary that there should be at least one observer in every county in the state, which can only be accomplished by the co-operation of the state with the Signal Service, by

furnishing instruments to a portion of the observers, as the rules of the United States Service prevent their furnishing outfits to observers at less distance than fifty miles from each other.

It is expected that during the present winter we will secure as many observers as the present regulations will allow within the boundaries of the state.

CHEMICAL WORK.

The work thus far done by the chemists consists of analyses of many ores, minerals, and mineral waters from various portions of the state, and a special study is now being made of the residue from lignite after distillation. This has been undertaken to ascertain what the probable commercial value of such residual products would be, and the practicability of using them in the conversion of lignite into a merchantable fuel.

An examination and study is also being made of the various soils of the state, especially those of the Panhandle and the Pecos valley. The latter comprise both arable and alkaline soils, and their analysis, together with that of the water of the Pecos River, will certainly be of great value in the proposed irrigation movements.

None of the chemical work has progressed far enough to be reported in detail at this time.

REPORTS OF GEOLOGISTS.

Prof. Streeruwitz reported for duty on the 29th of September, and at once began his preparations for field work. His instructions were simply to make a careful investigation of the mineral and agricultural resources of so much of the territory lying between the Rio Grande and Pecos rivers as he found practicable in the short time at his disposal. His report is referred to for particulars of his operations. Among the valuable results of his work is demonstration of the fact that the numerous valleys between El Paso and Fort Davis, which are now little better than deserts from lack of water to support vegetation, are in reality of fertile soil, as well protected as those in the vicinity of El Paso, and fully as suitable for grape and fruit culture, and that it is entirely feasible, owing to the natural formation of the country, by building dams at suitable locations, to reclaim and render fertile a considerable portion of these now useless valleys, and that the annual rainfall is amply sufficient to furnish water for this purpose.

His examinations and the specimens he sends of his own collecting from the mountain ranges in his district are sufficient to prove that they are mineral bearing districts of very considerable richness, and that it is highly important that a much more detailed examination be made of the entire district, and a report issued showing its true value as mineral land.

Prof. Cummins reported for duty on October 2nd, and shortly after took the field, with instructions to make a section of the Central coal formation, determining the number of seams of coal which exist in it, the approximate thickness of each, together with the character and thickness of the associated rocks; and also to investigate several localities where minerals of special value were supposed to be, and to make such observations on the conditions favorable to obtaining artesian water as was possible in this limited time.

The inclement weather of November interfered with his work to a considerable degree, but the results as presented in his report, incomplete though it be, give us a clearer and more exact knowledge of that part of our great central coal fields than has ever before been presented. If we take into con-

sideration the positive and urgent needs of this state for a supply of cheap fuel, and view these results in the light of that need, the great value of this knowledge will be readily apparent to all.

In order that the information obtained may be turned to practical use, this coal basin should now be carefully mapped and described, showing the localities of the different coal seams, their extent, and where they can be reached.

Owing to existing engagements, Dr. Penrose did not report for duty until November 12th. He immediately thereafter began work by proceeding to Jefferson to investigate the iron, limestone, and asphaltum deposits, the salt of Van Zandt County, and the petroleum of Nacogdoches, with further instructions to make a section of the lignite formation in order that we may have a correct knowledge of the location and thickness of the various deposits of these coals.

His report shows in a clear and comprehensive manner the character of the various grades of iron ore of his district, and their mode of occurrence, and also includes a partial account of their distribution and localities. The various lignite deposits were also examined, as well as the salt at Grand Saline, though only in a hasty manner, leaving a more detailed examination for a later report. When it is taken into consideration that this report is the result of only three weeks' work, and in a region entirely new to him, its extent and detail is even greater than could have been expected.

Instead of appointing a geologist in charge of Southern Texas, it was apportioned to three gentlemen selected to make special reports on certain counties. Mr. J. Owens, of Eagle Pass, was instructed to make report on the counties of Maverick, Kinney, Webb, Val Verde, Zavala, Encinal, and the lower Rio Grande.

Gillespie, Blanco, Kerr, Kendall, Comal, Bexar, Guadalupe, Wilson, Gonzales, and Caldwell counties were assigned to Professor Gustav Jermy, of San Antonio.

Col. Jno. L. Tait, of San Antonio, was selected to make investigations and report on Bandera, Edwards, Medina, Frio, Atascosa, La Salle, and McMullen.

The instructions given these gentlemen were to make examination and report on the economic minerals, building stones, etc., of the counties assigned them, and their attention was directed to such special subjects in each district as seemed worthy of careful investigation.

The results, as shown by their reports and the specimens sent in by them from these districts, are contributions to our knowledge of the counties examined which are most valuable to the whole state.

Work was very much impeded by the constant rains of November, and Prof. Jermy was unable to visit certain localities at which deposits of some value are supposed to exist. The valuable building stones which he brings to notice, specimens of which are in our cabinet, must prove of great benefit to the district, while projected railroads will shortly open up the rich iron field which he describes.

Col. Tait visited all the counties assigned him, with the exception of McMullen, but his observations were also interfered with by the inclement weather. He succeeded, however, in discovering the origin of the fine deposit of kaolin of Edwards County, and the existence of still other similar beds at other places which will doubtless prove equally valuable. His discovery of pure chalk is one of real interest, and his designation of a petroleum basin in Atascosa County a fact of great importance.

The report of Mr. Owens shows an extensive coal field on the Rio Grande, some of the seams being of very good thickness. There are samples of these coals now at the laboratory for analysis and report. He estimates the area of

the two fields at 3700 square miles. In addition to this, the building stone and bituminous sandstone of that section are well worth detailed examination. His observations in regard to the possibility of irrigation and the resulting fertility of the soil are in full accord with those of Prof. Streeruwitz in the Trans-Pecos, and his designation of the district within which artesian water can certainly be obtained, is a work that will surely be appreciated by every person in his district.

The great mineral district of which Llano County may be termed the centre has not been overlooked or disregarded, but no special investigation has yet been directed there, because from surveys made by myself, Prof. Streeruwitz, and others, its resources and geology are perhaps better known than those of any other portion of the state of equal area. My attention in this preparatory work has, therefore, been directed to sections of which we knew less.

A preliminary report on the building stones and minerals of the San Saba portion of this district has been prepared by Dr. A. Gregg, and will be found in its proper place.

MINING LAW.

In connection with these reports, I can not too earnestly urge the imperative necessity for a change in the mining laws of the state. The present statute, instead of encouraging prospectors and miners, operates as a preventive. While all investigators, without exception, concur in declaring Texas rich exceedingly in mineral deposits, of a variety and value unsurpassed by those of any state or country in the world; while these deposits occur in most favorable juxtaposition; while transportation facilities are rapidly increasing, and demand keeps pace with growing accessibility to market, our sister states are outstripping us in progress of development, and the richer fields of Texas lie unheeded and almost untouched. There are several reasons for this; one has been removed by the establishment of the present survey, but the chief existing one lies in the repressive mining statute now in force.

The provision of the law most obnoxious is that reserving mineral rights to the state and requiring a royalty of five per centum of the *gross* output of mines and the extreme narrowness of claim allowed. Although grave doubts are entertained as to the constitutionality of this provision, and though it may never have been and may never be operative, it nevertheless stands a stumbling-block in the way of progress in developing our mineral resources. Even if the reservation be constitutional, the tax is too onerous. Five per centum of the *net* proceeds would be burdensome, and the payment of royalties to the state at all savors too much of the monopoly of monarchies to suit the free spirit of our people. The state should ascertain the value of her mineral lands, place a fair value upon them, and sell them outright to actual miners under proper restrictions as to amount of work to be done. Such a course would be more agreeable to the genius of our institutions, and the resulting increase of taxable values would be ample royalty.

IRRIGATION.

Again, the importance of the work of the Geological Survey in connection with the subject of irrigation can not be too strongly urged. The classification of irrigable lands must include not only an investigation of their topography and a determination of the possibility of irrigation, but it is even of

greater importance that the character of the soil and subsoil be studied together with that of the water supply as well as all surroundings which may effect its quantity or availability for irrigation purposes.

Irrigation can not be carried on to that extent commensurate with the needs or possibilities of this State without this careful investigation, and it is therefore the part of wisdom to have these examinations properly made before the inception of the work rather than permit the inevitable loss of money which is sure to follow if each is left to work for himself.

RESPONSES TO CIRCULARS.

While by knowledge previously acquired I was in some degree prepared for many responses and much valuable information in reply to Circular No. 3, yet the number of letters received within three weeks, and the importance of their contents, has far exceeded my most sanguine expectations, and attest beyond controversy the deep interest felt by the people in the objects of the survey, and the urgent necessity for a more active and expansive prosecution of the work than is permitted by the present appropriation. I knew that Texas possessed vast wealth hidden in her broad bosom, that her deposits of minerals were extensive and of great variety, that the field of work undertaken was wide of scope and sufficient to tax the energies of the most efficient; yet as the volume of information increased day by day, lengthening and broadening my sphere of labor, disclosing an infinite variety of objects demanding immediate attention, and developing sources of wealth and avenues of industry stupendous in their magnitude and almost boundless in their extent and diversity, I felt that my previous knowledge was but as a bird's-eye view compared with the magnificent expanse opening before my mental gaze. The temptation thus offered to enter the field of speculation as to our great state's near future is almost irresistible; but knowing that what is desired in this report is fact, and fact only, I confine myself to a brief summary of the information received, hoping that the simple recital will be convincing of the urgent necessity for an active and energetic prosecution of the work so imperiously demanded by the exigencies of our condition.

From the mass of correspondence I condense the salient features reported, as an indication of some of the work to be done, the object of the correspondence being merely to secure a guide to the future work of field parties.

Artesian Wells.—A number of these wells have been sunk in various parts of the state with more or less success, and sections of many of them have been received. These sections are of great value to the survey as aids to the determination of the stratigraphy of the country, especially when samples of each stratum are preserved and forwarded with the section. This has been arranged for with several artesian well borers, and glass tubes of suitable size will be furnished to those who will do us similar service. I have pointed out the work to be done by the survey, in reference to artesian wells, in that portion of this report treating of that subject, and need not repeat it here.

Asphaltum.—At present, definite reports from correspondents of deposits of asphaltum, with specimens, have been received from Martin, Blanco, and Travis counties only, but it is known to exist in other localities as well. Many tar springs and deposits of a bituminous sandstone are also well known. The need of this substance for paving and other purposes is constantly increasing, and it is therefore important that the localities where they are reported to exist, should be examined, that we may ascertain whether our needs may not be supplied from our own deposits, instead of our being dependent upon those of Trinidad.

Building Stones.—Our correspondents describe the stones of several counties, and the investigations of the geologists show that the building stones of the state are not only widespread and of great variety, but that they are in many instances of very superior quality and great beauty. To make our resources in this respect as available as their importance demands, a special effort should be made to obtain specimens of each, and by actual tests to determine their strength and durability.

Bat Caves.—Numbers of these are reported from Williamson, Burnet, Llano, Blanco, Bandera, Uvalde, and other counties, containing many thousands of tons of bat guano, which analysis has proved to be fully equal to the imported article. The present condition of the Peruvian guano industry is forcing manufacturers of artificial manure to look elsewhere for their supplies, and a proper examination and exposition of our deposits will prove these to be their most available resource.

Clays.—These are reported in all varieties, from marls to the finest grades of kaolin. Fire clays are reported from a great number of counties, and specimens which have been sent in certainly warrant a careful investigation of them. Pottery clays are also reported abundant, and their value is no longer questionable, as the ware manufactured from them, now in the museum, removes all doubt. I am satisfied that a careful examination to ascertain the different localities, varieties, and extent of the deposits of these clays, supplemented by a statement of the proximity of all other requisites for the manufacture of earthenware and china, would be the means of securing the erection of potteries in several sections of the state.

Coal.—The reports of coal are so numerous that they can not be even generalized. They embrace specimens from many localities, descriptions of shafts sunk, and much information regarding thickness of veins, etc., and will prove of value in the prosecution of future investigations.

Gypsum.—Though the immense deposits of gypsum which exist in northern Texas have long been regarded as among the largest in the world, new localities have lately been given and fine specimens sent from places hitherto unreported. The remarkable amount of this mineral in this state (in some parts so great as to be really detrimental in its effects) demands a careful study for the purpose of finding additional methods for utilizing it to those now employed. It can be obtained of any required degree of purity and in quantities inexhaustible for any purpose.

Precious Metals.—Reports of the existence of gold, silver, and platinum continue to be received from various parts of the state, but no specimens of real value have been sent in from places outside of recognized mineral districts. Several of the localities reported, however, will be examined at an early day.

Iron.—Like those of coal, iron deposits cover a large portion of the state, and reports received develop the fact that good iron ore is found in places from which it had not been previously reported. Definite information, however, cannot be given concerning these new discoveries until proper investigations have been made.

Irrigation.—The extent to which this has been carried and proposed is well brought out by the replies to our interrogatories. The practicability of it in numerous other localities is also clearly determined, and it is hoped before long to embody all these results in a bulletin.

Mineral Waters.—Prodigal as Nature has been in many things in Texas, in none has she shown greater bounty than in the diversity and distribution of mineral waters. Besides many natural wells and springs, many artesian wells have been developed, which are rich in mineral impregnations. De-

tailed descriptions, however, cannot be given here, but must be left for the more accurate and careful work of the geologists and chemists, as time will permit. Special attention will be given them as opportunity offers.

Natural Gas.—This valuable fuel, which has taken its place within the last few years as one of the most important factors in the progress of the United States, is reported at many places in Texas It is known in Grimes, McLennan, Young, Lavaca, Washington, Grayson, Sabine, Hardin, and other counties. Boring is now being done at Greenvine, near Burton. Two wells have been completed, both of which yield fine flows of gas. From the manager we learn that the first well was finished November 1st, and the anemometer measured 280 feet per minute. The gas was found in a porous sandstone at a depth of 152 feet. The second well was sunk about 900 yards from the first, and gas was found at a depth of 134 feet, 127 of which was variously colored clays, alternating with sand, underlaid by 12 inches of coarse gray sandstone, under which was a hard blue limestone 2 feet in thickness, which again was underlaid by a very soft blue sandstone 4 feet thick. The yield of this well, as measured by the anemometer, was 445 feet per minute. The success of these wells will doubtless stimulate the search for other indications of gas, and affords a basis for further geologic study and investigation with a view to the determination of its probable existence or non-existence in given localities.

Petroleum.—If under this head the heavy lubricating oils are included, we have some very valuable fields beside those already partially developed in Anderson and Nacogdoches Counties. It is known to exist in many places in eastern and northern Texas, and is reported from Cass, Travis, McLennan, Harr son, Cooke, Jasper, Grimes, Robertson, Bexar, Brown, Coleman, Burnet, and other counties. Work in the matter of studying its geologic chara ter, position, and extent will be begun as soon as possible.

Sa t.—The great extent of the salt deposits of Texas is not properly appreciated. Reports from nearly every section of the state show evidences of salt, and some of the deposits are of astonishing extent. In several places it is being manufactured by the evaporation of brine, while at other places the deposits formed by natural evaporation are being dug and used. In addition to this a deposit of rock salt at Mangum, in Greer County, is reported as being worked, and the recent reported discovery of a similar bed, more than 125 feet thick and of unknown extent, at Grand Saline, in Van Zandt County, adds greatly to the value of that locality.

Soils.—One of the most urgent needs of the state at present is a proper study and classification of its great variety of soils. Very little systematic work in this direction has been carried on in this country. The most important was that done under the tenth census of the United States. Correspondents are sending in samples of characteristic soils from many sections, and it is proposed to examine these and to secure all others necessary to a complete analysis and classification.

Our correspondents also send us notice of the occurrence, in various portions of the state, of many minerals of less moment than those mentioned, but which will nevertheless be of great value in the aggregate.

The number of correspondents is too great to mention by name those to whom we are under obligations for facts communicated. I therefore avail myself of this opportunity to tender them, one and all, my heartiest thanks for the promptness and fullness of their replies and the interest they have manifested in the success of the survey.

COAL.

There are in Texas three distinct coal fields—the Central or Bituminous, the Nueces or Semi-Bituminous, and the Lignitic.

The Central Coal Field is a continuation of the Missourian, or fourth coal basin of the United States, of which it is the southern extremity. Its approximate boundary is a line from the eastern corner of Montague County, running southwest from Red River just west of Decatur and Weatherford, through the southeastern corner of Palo Pinto County, and west of the town of Commanche to the eastern line of Brown County. From this point it runs more directly south, passing through Lampasas into Burnet County, where the formation has its most southern exposure so far as at present determined. On the west it appears again in Kimble and Mason counties, and the line running north passes through Menard, Concho, Runnels, Taylor, Callahan, Shackelford, and Throckmorton counties. through the southeastern portions of Archer and Clay to the mouth of the Little Witchita. This field covers in whole or in part some twenty-five counties, and has an area of not less than twelve thousand square miles. Its eastern border is overlaid by the rocks of the Cretaceous formation, while the Permian beds rest upon it on the west.

The section made by Prof. Cummins shows the thickness of the formation to be not less than 2000 feet, with nine seams of coal, of which two at least, and probably three, are workable. The work which has been done on the central portion of this field is fully detailed by Prof. Cummins.

Prof. Chas. Ashburner, who made a partial examination of these coals in 1879, saw no coal stratum lower than that found four and a half miles northwest of Crystal Falls, in Stephens County, which he named the Brazos Coal Bed. He says: "The coal strata proper are 85 feet thick, and are included between an upper sandstone and conglomerate and a lower gray limestone. The coal strata contains two beds of workable thickness. The upper, named Belknap, ranges from $2\frac{1}{2}$ to 4 feet, and the lower, named Brazos, from 4 to 6 feet in thickness. The coals are high in ash and sulphur, but have never been thoroughly tested. The Brazos bed underlies a great area, and will no doubt prove to be a valuable commercial coal in some localities."

These two beds may be still higher than those reached by Prof. Cummins, or they may belong to his seams number 7 and 8. His examination will soon determine this fact.

Specimens of these coals will be subjected to analysis at once in order to ascertain their true value.

The Nueces Coal Field.—The Neuces or semi-bituminous coal field, as described by Mr. Owen, includes parts of Webb, Dimmit, Zavala, and Maverick counties, and has an area of thirty-seven hundred square miles, and the northern boundary not yet determined.

It contains two workable seams of coal and locally at least three. These differ somewhat in character, the lower is a semi-bituminous coal, probably of cretaceous age, which, so far as it has been examined, gives promise of being a very good fuel. It is being worked north of Eagle Pass at the Hertz mines.

The other bed, which is now being worked at San Tomas, is possibly of the Laramie group but can hardly be older. It is really somewhat lignitic, although, as Mr. Owen states, quite different from the lignites of our Tertiary coal field.

Another variety which is also found in some quantity in this coal field is Albertite. Specimens of this were collected by Dr. Geo. G. Shumard, in 1860–61, but I find no mention of it in his manuscript. This seam is northeast of the San Tomas exposure and will prove valuable.

Mr. Owen submits specimens of the various varieties with his paper and they will be examined and reported on as soon as possible.

It is proposed to give this district a careful and detailed examination at an early day.

The Lignite Field is by far the largest field we have and the coal strata it contains are of much greater thickness than those of either of the others. As nearly as we can at present mark its boundaries, they are as follows: Beginning on the Sabine River in Sabine County, the boundary line runs west and southwest near Crockett, Navasota, Ledbetter, Weimar and on to Helena and the Rio Grande, thence back by Pearsall, Elgin, Marlin, Richland, Salem, and Clarksville to Red River.

It includes fifty-four counties in whole or part, and while we do not know of the occurrence of lignite in every one of these, it will in all probability be found in all of them sooner or later.

We are able to recognize four, possibly five, strata of lignite in this field, one of which attains a thickness in many places of from fifteen to twenty feet. The others vary in thickness from a few inches to five feet. The amount of sulphur contained in these lignites is very variable, as is indeed the quality of the lignite itself. In some places we have a good clean lignite, almost if not entirely free from sulphur, while at other places masses of sulphuret of iron are mingled through a carbonaceous mass.

Very little work has been done in this coal field because it has, up to the present time, been regarded as of little or no value. Two causes have been instrumental in creating this impression; first, the quality it possesses of rapidly crumbling and slaking when exposed to the air, and second (and perhaps this is the principal cause), because nearly all who have attempted to use it have done so without first studying its character and the best methods of burning it, and they have in most cases endeavored to use it under the same conditions which apply to a heavy bituminous coal containing little water.

While lignite may not differ materially from bituminous coal in weight, its physical properties are entirely different. This fact is due not only to the amount of water contained in the lignite, amounting to from ten to twenty per cent of its weight, but also to the fact that it is the product of a different period of geologic time and that its original vegetable growth was of somewhat different character from that from which bituminous coals were formed.

Therefore, in any intelligent effort to make it available for fuel, these considerations must be taken into account and proper allowances made for them. In Europe where fuel is scarcer than here, lignites of much poorer quality than the average of our deposits are successfully used not only as fuel for domestic purposes but also in smelting. Furnaces of simple construction have been contrived, in which by a judicious treatment, lignites are made to do full duty as fuel for any purpose. In our own State, at San Antonio, where fire wood is somewhat scarce, and bituminous coal expensive, very satisfactory results have been secured in burning lignites by using grate bars close together.

In addition to this, they are also reduced to powder and compressed into briquettes, which have a cementing bond of starch or asphaltum. This class of fuels is used almost exclusively on the French railroads.

The finding of the beds of asphaltum (which have been described under that head) makes this plan of utlilization a matter of easy accomplishment in Texas, and compressed fuel made from Texas lignite and Texas asphaltum

can be prepared equal to any coal now brought into the state for steam and domestic use, and at a price below that of the cheapest of them.

In addition to this, the chemist of the survey is now engaged in making a series of determinations in order that we may know the amount of pitch and commercial products—benzine, aniline dyes, etc.—which our lignites will yield with proper treatment, and that we may form an idea of their commercial value when treated in this manner.

The amount of this material reported by numerous correspondents and known to us to exist throughout the state warrants the strongest effort to prove its availability as a valuable fuel.

ARTESIAN WATERS.

The necessity for a greater supply of water, and that, too, of greater purity, than can be secured by the means of shallow wells or from streams and tanks is one that is making itself felt more and more strongly in many parts of Texas. A few localities which happen to be most fortunately situated have solved this momentous question for themselves by securing artesian water, while other places have spent their money in vain in an effort to reach these subterranean streams.

In order that those who are directly interested in this matter may rightly understand the conditions necessary to the probable existence of artesian water beneath them, and the direct bearing which the Geological Survey will have on the determination of the boundaries within which such wells may be looked for with confidence, and those places where they are an uncertainty or can not be found at all, the following abridgment of a discussion on the "Conditions of Artesian Wells," by Thomas C. Chamberlain, in the Fifth Annual Report of the United States Geological Survey, is given:

CONDITIONS OF ARTESIAN WELLS.

While the elementary principles of artesian wells are simple and known to every schoolboy, the real problems they present are complex. Some of these principles are best explained by the following ideal sections and the explanations given with them. The first represents the chief requisite conditions of artesian wells, while figures 2 and 3 show some of the variations possible:

FIG. 1.

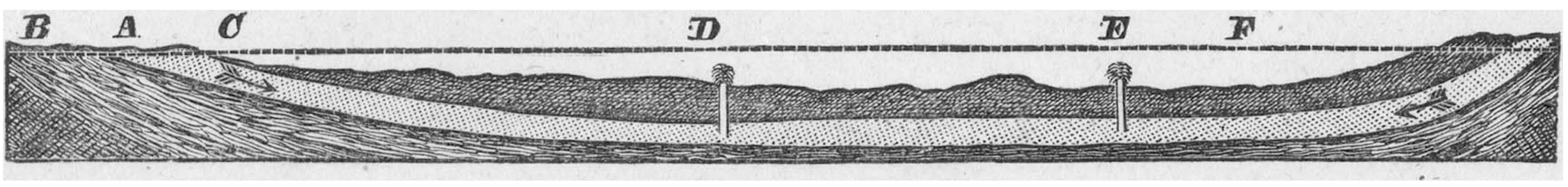


Fig. 1.—Ideal section illustrating the chief requisite conditions of artesian wells. A, a porous stratum; B and C, impervious beds below and above A, acting as confining strata; F, the height of the water level in porous bed A, or in other words, the height of the reservoir or fountain head; D and E, flowing wells springing from the porous water-filled bed A.

FIG. 2.

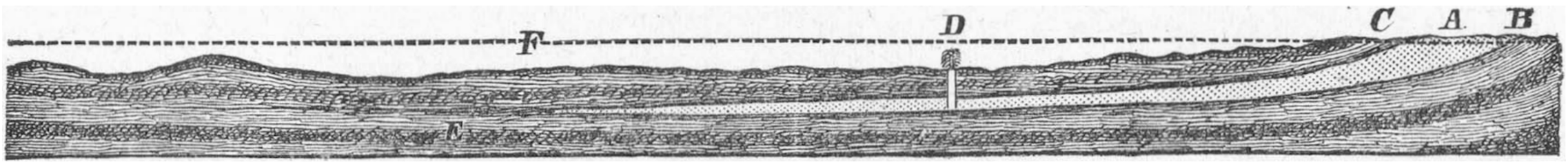


Fig. 2.—Section illustrating the thinning out of a porous water-bearing bed, A, inclosed between impervious beds B and C, thus furnishing the conditions for an artesian fountain D.

FIG. 3.

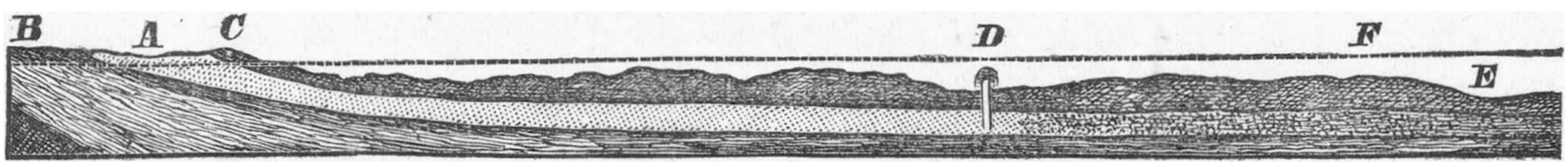


Fig. 3.—Section illustrating the transition of a porous water-bearing bed, A, into a close-textured impervious one. Being inclosed between the impervious beds B and C, it furnishes the conditions for an artesian fountain D.

ESSENTIAL FEATURES OF ARTESIAN WELLS.

The artesian stream has its source, its underground water way, its ascent through the well, and its final descent in the rill that runs away. It is peculiar mainly in its underground conditions. Upon these chiefly the ascending flow depends.

Typical Examples.—To fashion a simple idea of the common class of flowing wells, picture to the mind a pervious stratum through which water can readily pass. Below this let there be a water-tight bed, and let a similar one lie upon it so that it is securely embraced between impervious layers Suppose the edges of these layers to come to the surface in some elevated region (save that they may be covered with soil or loose surface material), while in the opposite direction they pitch down to considerable depths, and either come up again to the surface at some distance, thus forming a basin (Fig. 1) or else terminate in such a way (Fig. 2) or take on such a nature (Fig. 3) that water can not escape in that direction. Now let surface waters penetrate the elevated edge of the porous bed, and fill it to the brim. That such beds are so filled is shown by ordinary wells, which commonly find a constant supply in them at no great depth. Now it is manifest that if such water-fat bed be tapped by boring at some point lower than its outcrop, the water will rise and flow at the surface, because of the higher head in the upper edge of the bed. If the surface water continually supplies the upper edge as fast as the water is drawn off below the flow will be constant.

Prerequisites.—The leading conditions upon which artesian flows depend are involved in this simple conception. Drawn out, they are as follows:

I. A pervious stratum to permit the entrance and the passage of the water.

II. A water-tight bed below to prevent the escape of the water downward.

III. A like impervious bed above, to prevent escape upward, for the water, being under pressure from the fountain head, would otherwise find relief in that direction.

IV. An inclination of these beds so that the edge at which the waters enter will be higher than the surface at the well.

V. A suitable exposure of the edge of the porous stratum so that it may take in a sufficient supply of water.

VI. An adequate rainfall to furnish this supply.

VII. An absence of any escape for the water at a lower level than the surface at the well

Considering these in detail, we have first

THE WATER-BEARING BEDS.

There are two general methods by which water finds its way through the strata; in the one—the rock being close-textured—the water passes through fissures formed by fracture, or through tubular channels formed by solution; in the other—the rock being open-textured—the water sieps through the pores, permeating the whole bed.

1. *Fissured or Channeled Beds.*—Beds that offer only crevices and channels as water-ways are a very uncertain source of fountains, since the position of such channels can not be determined beforehand. The close-textured rocks that fall under attention here are chiefly the granites and similar crystalline rocks and the limestones (which, however, are sometimes locally serviceable). The clay rocks (shales, etc.) are too compact to be in any available degree water-bearing; indeed, they form the chief confining strata.

2. *Porous Beds.*—Quite in contrast with the close-textured beds that are water carriers only by virtue of fissures and channels, are the open-textured strata that constitute continuous water-filled sheets underspreading wide areas, and which can therefore almost certainly be tapped at the proper depth. Speaking in general terms, these are the only reliable sources of artesian wells.

To this class belong beds of sand, gravel, sandstone, conglomerate, and other less common rocks of loose granular texture. Some of the more porous chalks and granular limestones may also be classed here. The common feature of the class lies in the construction of the rock from separate particles, loosely put together, leaving small open spaces between them. A bed of sand is a typical illustration, and it will not be wide of the truth to speak of the whole class as sandstones. All sandstones, however, are not porous enough to furnish a ready passage for water, the interspaces being filled with clay or other impervious matter, or they may be compacted by pressure.

The degree of porosity is a very important consideration, and in general the larger the sand-like particles are, the greater the water carrying capacity. The rule that the older the formation the greater the degree of consolidation can not be relied on, but the capabilities of each formation must be ascertained by direct observation of its constitution, and it is suggested that these examinations be made more critical.

THE CONFINING BEDS.

While no stratum is entirely impervious, one which successfully restrains the most of the water and thus aids in yielding a flow is serviceably so. The nearest approach to an entirely impervious bed is furnished by a thick layer of fine unhardened clay. Clayey shales rank next, followed by shaley limestones, shaley sandstones, the crystalline rocks, and compact limestone, and even water itself under certain conditions.

1. *The Confining Stratum Below.*—The confining stratum below the porous bed demands less attention than the one above it, for if the layer next

beneath the water bed is not perfectly impervious some lower layer will stop the water, and as the lower strata of a basin generally outcrop at higher elevations than those overlying them, they do not carry the water to the surface at a lower level than the head of the upper water bed.

FIG. 4.

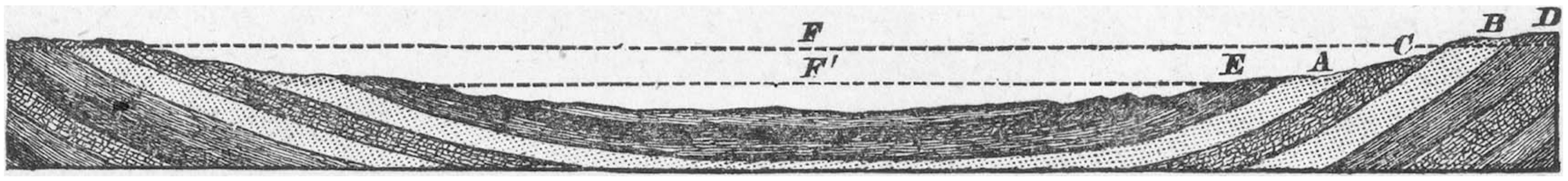


Fig. 4.—Section illustrating the usual order in which the strata come to the surface. A and B, porous beds; D and E, impervious beds; C, a half impervious bed; F′ and F, the water levels of A and B, respectively.

The only defect in this would be in case of erosion as shown in accompanying figure.

FIG. 5.

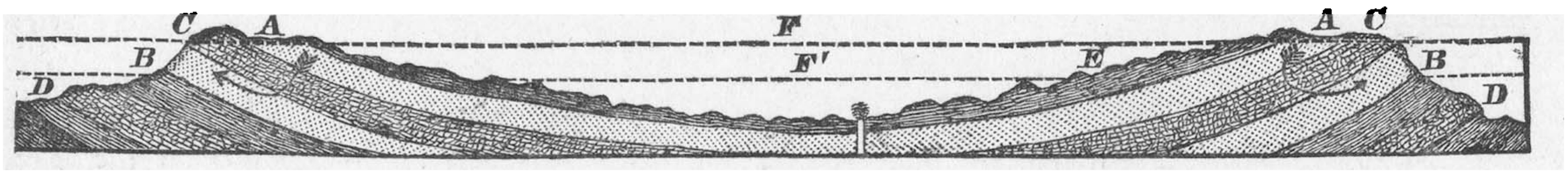


Fig. 5.—Section illustrating the possible effect of erosion upon strata originally like those in Fig. 4. A and B, porous beds; D and E, impervious beds; C, a half pervious bed; F and F′, the water levels of A and B, respectively. If the stratum C is not practically a confining layer, the water from A will pass through it and escape at the edge of B, so that a flow can not be obtained at a higher level than it, but may be had below the line F′.

2. *The Confining Stratum Above.*—The character of the strata that overlie the water-bearing bed is critically important, for the water being under pressure, tends to rise through them, and if they are in any degree penetrable it will to that extent escape, relieve the pressure and thus reduce or prevent the flow.

a. Leakage will be reduced in proportion as the pressure is lessened. In nearly balanced cases, the loss is less—other things being equal—than in cases of high head and free passage, *but it is more critical in determining success or failure.*

b. The most essential consideration, the character of the rock, has already been discussed.

c. Efficiency increases with thickness of overlying beds. If the cover beds are of the highest impervious character, there is little need that they should be very thick, but when the degree of imperviousness is inferior, the element of thickness is not without consequence, in itself, and, taken in connection with the following point, may be decisive.

d. If the surface water (*i. e.* shallow wells) between the well and the fountain head stands as high as the fountain head, there will be no leakage. If underground water surface is lower than the fountain head, there will on the contrary be considerable leakage. I conceive that one of the most favorable conditions for securing a fountain is found where thick semi-porous beds, constantly saturated with water to a greater height than the fountain-head, lie upon the porous stratum, and occupy the whole country between the well and its source. This is not only a good, but an advantageous, substitute for a strictly impervious confining bed. Under these hydrostatic conditions, limestone strata reposing on sandstone furnish an excellent combination.

THE INCLINATION OF THE BEDS.

The water-bearing bed and the confining strata that embrace it must be inclined so that the edge which comes to the surface shall be higher than the surface at the proposed well. Their position and condition may be that indicated either by cuts 1, 2, or 3. Sandstone strata are chiefly the product of wave-action along shore belts and off shore shallows. They are thickest and coarsest along the shore edge and thinner and finer in the off shore portion. When these beds are afterward lifted and become part of the continent the former shore border is almost universally most elevated and becomes the entrance edge for subterranean waters.

Height of Outcropping Beds.—The relative height of the outcropping edge of the water-bearing stratum is a consideration of the highest importance. This edge must be elevated so that the water will stand high enough above the site of the proposed well to force an efficient flow, after deduction is made for leakage and the obstruction encountered in the passage. How much higher, is a complicated question, depending on (1) the distance of well from source of supply; (2) the capabilities of the porous bed; (3) the character of the confining strata, and (4) the topography and ground water surface as before explained.

THE RESERVOIR OR FOUNTAIN HEAD.

As has already been indicated, the reservoir is neither a surface lake nor an underground pool, but is simply (in most cases) the water contained in the water-bearing stratum above the level of the point of flow. This is supplied by the rainfall.

THE COLLECTING AREA.

The outcropping edge of the porous stratum is practically the collecting area. Its extent depends not only on the thickness of the bed, but also on the angle at which it comes to the surface, and the amount of erosion it has undergone as illustrated below.

FIG. 6.

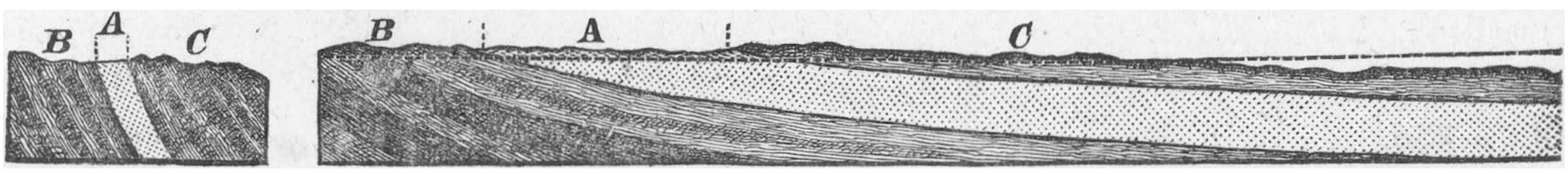


Fig. 6.—Section showing the dependence of the collecting area on the thickness and slope of the porous beds. In the left-hand figure the porous bed A is thin, and coming to the surface at a high angle, gives but a small section. In the right-hand figure the bed A is thick, and coming to the surface at a low angle, its beveled edge is broad.

FIG. 7.

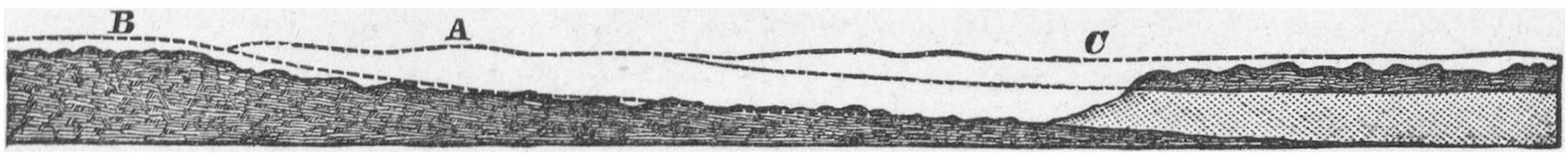


Fig. 7.—Illustrating a common effect of erosion upon the surface area of the porous stratum and the contour of the resulting basin. The dotted lines show the original contours.

If the region of outcrop is much elevated and the surface slopes are rapid, the rainfall runs quickly away and a less proportion is absorbed than in flatter regions where the discharge is less rapid and the water has an opportunity for percolation. It is evident, therefore, that the amount of water contained in the water stratum depends on the porosity of outcrop, and the extent of its usefulness depends on the gentle inclination of its receding stratum.

RAINFALL.

For the ultimate source of these fountains we are manifestly led up to the clouds, and the chief question relates to the adequacy of the supply they pour out upon the collecting area. This area is only the outcropping edge of the porous stratum, and an adequate supply of water by means of rainfall must be sufficient to fill the water-bearing bed to such a height that it will give a flow at any favorably located point in the distance. Less than this is inadequate. This is the most important factor of all.

Bearing in mind the conditions as explained by Mr. Chamberlain, the work of the Geological Survey is readily apparent.

It comprises a careful examination and study of all the different geologic formations of the state to ascertain the exact character of each stratum, and to determine which of these are sufficiently porous to act as water carriers, and if any of these are properly confined between impervious beds, so as to retain the water and yield it up upon boring. The order in which the strata succeed each other, together with the average thickness of each and the direction and extent of the dip or inclination, must also be carefully observed. Then the outcropping edges of the different formations must be carefully designated on a topographic map, showing not only the height of the outcropping strata, but the extent of the collecting area. The amount of rainfall on such area must also be determined by actual observation to ascertain its adequacy or inadequacy. By adding to these a series of sections constructed to show the position of the various strata below the surface, based on the calculations made from the observations mentioned above, the probability of obtaining artesian water at any given locality can be known, as well as the approximate depth to which boring would have to be carried to reach it.

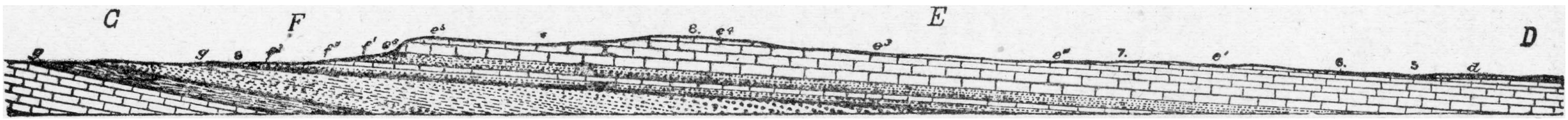
As a practical example of such work done in Texas, the following results of a survey made by Prof. R. T. Hill gives us important information about the artesian water of Fort Worth and Dallas. This survey was made along the line of the Texas and Pacific Railway from Elmo, Kaufman County, to Milsap, Parker County, and the cuts given below are a complete section connecting these points:

FIG. 8.

TOPOGRAPHY.

A—Van Zandt post oak and sandy prairie region, marking the western border of the great Atlantic timber belt, and of the Tertiary formation. B—The true black waxy prairie of Texas, consisting of (1) calcareous clays (at Terrell), (2) chalk marls, and (3) gray chalk or white rock (Dallas). C—The hog wallow black prairie belt west of Eagle Ford. D—The sandy region of the Lower Cross Timbers. E—The hard lime rock prairie between Handley Station and Weatherford, as seen at Fort Worth. F—The Upper Cross Timbers between Weatherford and Millsap. G—The Coal-measures west of Millsap. (1) Terrell, (2) Dallas, (3) Eagle Ford, (4) Arlington, (5) Handley, (6) Fort Worth, (7) Benbrook, (8) Weatherford (9) Millsap.

FIG. 9.



STRATIGRAPHY.

A—Basal sands of Tertiary resting uncoformably upon B. B, C, D—Upper Cretaceous. a—Calcareous clays. b—"White rock" or gray chalk, as at Dallas. c—Dark blue clay shales. d—Ferruginous sands and lignite. E, F—Lower Cretaceous. e^1, e^6—Various horizons of impervious limestone. f^1, f^3—Water-bearing strata of Trinity formation. g—Impervious beds of Carboniferous. (The dip of the latter is incorrect in cut.)

Here we have at G the limestones of the coal formation underlying the beds of sand which constitute the exposed edge of the geologic formation on which the Upper Cross Timbers are situated, and which is in fact the receiving area for the artesian wells of Fort Worth and Dallas. These beds are marked f^1 f^2 f^3 in the cut and are overlaid in turn by the limestones of the chalk formation. The inclination of the sand bed is such that at Fort Worth it is reached at a depth of 350 feet, while at Dallas wells must be 750 feet deep to reach it. Knowing now the head of the fountain and extent of receiving area, if we take the known amount of rainfall for the district, we can readily determine the adequacy or inadequacy of the supply for these and intermediate places.

Artesian wells are now flowing in many sections of the State, so many indeed that we can not even enumerate them here, but there are also many other localities where supplies of water can be obtained in this way and these should be brought to notice by the work of the Survey.

DROUTHS.

The drouths which have prevailed in certain portions of Texas for a few years past seemingly possess some periodicity, and their results are so disastrous that it behooves us to put forth most earnest efforts in an attempt to prevent their continued recurrence, a work which to be effective must necessarily be initiated by the geologist and most appropriately under state direction.

The region affected lies between the ninety-seventh meridian of west longitude and the foot of the Staked Plain. It comprises a section of hilly country, which contains much sandy and porous soil, the streams frequently sinking and running under the sands rather than over them, consequently there is a very limited amount of exposed water either in streams or lakes, and also over the greater extent of the region a scarcity of timber growth. And, indeed, it may be said that the same conditions obtain over the entire western part of the state.

This evil is not altogether traceable to the lack of a necessary amount of rainfall, since the records of the Signal Service show that sufficient rain has fallen in every year, save one, to have matured the finest crops, had it only fallen at suitable times. The rain has fallen, but there being no suitable conditions for its retention, it has run off in floods, to carry damage to the lower lying lands and swell the waters of the gulf.

The question, therefore, narrows itself at once to that of a proper distribution of rainfall and the conditions necessary to secure this, or in the event of its impossibility, the storage of the surplus water from rainfall, and holding it so that it may be made available when needed. Thus the matter is resolved into a scientific problem, which, however, when solved, only demands the use of our every day common sense business methods for its proper utilization.

The two elements most serviceable in this solution are the existence of standing or running water and the presence of timber growth.

Although these are not the only essentials, their modifying influence is very marked.

The effect of water, either in running streams, lakes, or ponds, in causing an increase in the amount of rainfall in its vicinity is well understood. By constant evaporation it furnishes abundant moisture to the air and exerts a cooling influence upon the surrounding atmosphere, thus producing meteorologic and electric conditions favorable to rainfall.

The effects of forests are of even greater importance in this particular, as they are in fact great reservoirs for agricultural lands, giving up gradually throughout the season when it is most needed by the farmer, the store of water that has fallen over its area.

Rain which falls in an open country is only partially taken up by the soil, and the heavier the rain the greater the proportional loss of water. Rain which falls upon a forest, though it be heavy, has its force broken in some measure by the leaves and branches, and reaches the ground beneath to find a soil much more receptive than that of the open country, on account of its vegetable mold. Here the water, instead of rushing off in torrents, penetrates the soil down to the impenetrable subsoil, where it accumulates, appearing elsewhere as springs. Forests, by retarding the running off of the heavy rains, and by the consequent partial prevention of floods, cause the flow of streams to be more gradual, and to be continued more evenly through a longer period. This is especially true of forests on slopes and crests. In addition to these facts the climatic influence of the forest upon its neighborhood creates a shorter range of temperature and causes more permanent moisture in the atmosphere. These characteristics are more pronounced in summer than in winter.

The temperature of the forest air (interior) is also lower than that of the fields. This difference of temperature in the central part of Texas would probably reach as high as six or eight degrees and would be attended by all the consequences of reduced evaporation, cooler winds, and increased rainfall.

Here, then, are two most important factors in the proper distribution of rainfall, neither of which exist to the necessary extent in the drouth district. That this lack of suitable conditions should be properly supplied is an absolute necessity for the people of that section, and that it may be done intelligently, the following suggestions are offered as being in the line of work which properly belongs to the Geological Survey.

1st. The necessary supplies of standing or running water can only be secured by the erection of dams and construction of tanks or by sinking artesian wells, or better still, by a combination of the two wherever possible. It should, therefore, be the work of the survey to obtain a correct knowledge of the topography, drainage system and geology of the district in order that the most available places for building dams or tanks may be made known. These tanks would serve the purpose of storing water either to induce rainfall by change of atmospheric conditions, to render the growth of forest trees a possibility, or even when necessary, to be used for purposes of irrigation.

This will require both the topography and geology of the region, since in addition to mere location, the condition of permeability of the adjacent strata must be thoroughly known in order that the .tanks or dams may hold water, and also that wherever possible, artesian wells may be secured in the vicinity of tanks, the flow from which will compensate for the loss of water by evaporation from the tanks.

2nd. An investigation by the botanist of the survey into the kinds of timber growth best suited to the soils of this region and its present climatic conditions.

3rd. A careful study of all meterological facts bearing on the subject of drouths as influenced by other causes than those given should be made in order that whenever necessary the facts and remedies, so far as known, may be accessible to the people. For this purpose the meteorlogical work already referred to will give necessary and valuable data. These facts having been ascertained and made known, the building of the dams and the planting of

the forests, which are to produce the desired alterations of agricultural conditions, must devolve upon the people themselves to whom the benefits of such action will principally accrue.

CONCLUSION.

From the foregoing it will be clearly seen that the work thus far has been in the main preliminary and preparatory, and necessarily so, as the time which has expired since the organization has been too short to do more than get ready for the real work to be done, and to ascertain in what direction it is most needed. Yet it is hoped enough has been accomplished to show at least what there is yet to do, and to convince the most skeptical of its practical utility and value to the people as individuals and to the state as an entity.

The scope of the work is wide enough and the results to flow from it important and valuable enough to call for the active employment of all the skill and talent the state can command. The expenditure in this direction within the next two years of one hundred thousand dollars, together with the necessary change in our mining laws already indicated, would, I am satisfied, be repaid tenfold by the development and improvement of the country and the consequent augmentation of taxable values; and fiftyfold in the increase of our prosperity, and the consequent amelioration of the condition of our people. It would open up avenues for the investment and employment of surplus capital, multiply industries, and thereby create a demand for labor, giving occupation to those of our people now suffering from enforced idleness; render our agricultural population in a measure independent of the uncertainties of the seasons, by insuring a certain return for their industry and remuneration for their labor, by providing a ready market for their productions; give a stimulus to manufacturing, mining, and agricultural pursuits, which in turn would stimulate trade and commerce, and go far toward making Texas self-supporting, self-contained, and genuinely independent.

Respectfully,

E. T. DUMBLE.

REPORT OF GEOLOGIST FOR WESTERN TEXAS.

E. T. Dumble, Esq., State Geologist, Austin, Texas:

SIR—I left Austin October 3rd, A. C. I arrived at Sierra Blanca October 5th. The tent and barometer addressed to that place not having previously arrived, and not arriving during that day, I left for El Paso October 6th, leaving directions to forward the barometer. The tent, when it should arrive, I desired to be stored with Mr. Hutchins in Sierra Blanca until called for.

In El Paso I bought a team of light mules and a "South Bend" wagon at reasonable prices, had the wagon changed and fitted up to suit the purposes of the expedition, bought a camp outfit, and engaged men.

In obedience to your instructions to confine my work to the examination of the more important parts of the country, and not to make a detailed survey of any particular locality, I concluded to go over as much ground as possible, to make short stops only at such places as appeared to be of most importance with reference to economical geology, and to confine myself especially to this branch of the survey. I thought that in this manner I would best fulfill the spirit of the geological bill and serve the interests of the state.

October 11th.—I started to the Franklin range of the Organ Mountains, north of El Paso.

The mesa or high prairie land, which begins about three miles northeast of El Paso, rises nearly 200 feet above the level of the city, and at a somewhat greater distance it rises nearly 400 feet above that level. Its soil is a rich loamy sand of quaternary age, being the product of the decomposed rocks of the surrounding mountains. Its vegetation consists mostly of gramma grass, Spanish daggers, cactus, greasewood, and catclaws.

If it were possible to irrigate this, it would make excellent farming land, equal to the best in the state. This flat spreads between the Franklin range on the west and the Hueco Mountains on the east. The soil is mixed and covered with gravel only in the vicinity of the mountains.

The foothills consist mostly of a conglomerate of pebbles and boulders varying from a quarter of an inch in diameter to ten and twelve inches, and consist in part of limestone, granitic, and porphyritic rocks, quartz, quartzites, jasper, etc., with very few fragments of petrifactions of different periods. Under the fertile soil of the mesa, which, as some dry water-courses show, is from two to four feet thick, a number of well rounded pebbles of various sizes and material, evidently the debris of the foothill conglomerates, begin. I estimate the depth of this layer, which is imbedded near the surface in sandy, loamy, and calcareous soil, at not less than fifty to seventy feet, below which depth the calcareous deposits begin.

The whole mesa is "flat as a dollar," spreads about twenty-five miles east and west, and beginning near El Paso, extends far over the boundary line of Texas into New Mexico. This mesa is evidently a part of a former lake bed, although about 200 feet above the level of the prairies south and east of it.

Irrigation from artesian wells or the Rio Grande River is out of the question, but some of the valleys in the foothills and the mountains might be dammed at a comparatively small cost to form reservoirs of considerable size. Judging from the traces of washing in the water-courses, very heavy rains fall in this part of the state, by which such reservoirs would be supplied.

The float rocks from the mountains indicate that the rocks of the Franklin mountains are granite, granulyte, feldspar, and augitic porphyries, such as greenstone porphyry and melaphyre, and crystalline limestones. I found this confirmed by walking into the mountains proper and climbing along the steep slopes. The plutonic, and in some places the volcanic formations named above, are partly capped by crystalline limestone partly metamorphosed, which covers also the greater parts of the slopes on the river or western side.

Of the four springs on the eastern side of the mountains, only Monday Springs, thirteen miles from El Paso, contained water in sufficient quantity for camp purposes; another, four miles farther north, is higher up in the mountains and its water supply had dwindled down to a few gallons in twenty-four hours. The mountains of the Franklin range show, from a hurried and consequently superficial inspection, many good ore indications in the shape of whitish, yellowish, and reddish decomposed streaks, particularily in contacts, outblows of strongly ferruginous quartzites, and calcareous outcroppings.

The physiological effects of the water on myself and on my men, leads me to believe that the ores will be found in the shape of tellurides. This might account for the scarcity of older Spanish and Mexican prospects and mines, the tellurides not having been as well known to the Mexicans and Spaniards as the sulphides, carbonates, chlorides, etc.

In spite of this there exist traditions of mines successfully worked by Franciscan monks (for instance the "Padre" mine), but as is generally the case in such instances, either nobody knows the exact location, or the small holes and dumps contradict the truth of the traditions of extensive mines.

About four miles northeast of El Paso, a streak of marble outcrop runs across the mountains, and about eight miles from town I found some prospecting done on an iron outcrop, which may turn out to be the capping of a lead or more probably of a copper gangue, as all the metal bearing float pieces, except iron, which I found on the east side of the Franklin mountains, are copper bearing or at least copper stained.

October 12th.—I left wagon and team at Monday Springs, which are located 4700 feet above the sea level, and I found in my walk through the mountains some very strong quartz outcrops a mile above the springs, partly yellow tinted by oxide of iron, partly grayish and black streaked, principally, however, whitish gray and pure white. These outcrops would be regarded fully worth prospecting in any mining district of the United States or of other countries.

Similar quartz outcrops, although not as "big," are found in many other places of the mountains. Climbing up to a "saddle" between two peaks I reached the height of 5953 feet above the sea level, and scaling the limestone capping of the higher peak I reached the altitude of 6280 feet, and from an estimate I would say that there are single peaks of these mountains 200 to 300 feet higher still.

Climbing down 500 feet between the porphyry bowlders to a cotton-wood tree on the west or river slope, I found a strong spring of clear, cold water. I found in the foothills an old prospect hole in the limestone.

The west or river side slope of the Franklin mountains consists principally of the crystalline limestone mentioned above as the capping of the granitic and porphyritic mountains, and its foothills and mesa run out in similar conglomerates to those on the east side. Judging from the material of the rocks the outcroppings on this side indicate lead.

Having ascertained that these mountains, as far as they are located inside the boundaries of Texas, are of nearly uniform character, composed principally of the rocks mentioned above, I returned to camp. I knew the only pass to the river side through which it was possible to pass with a team to be in New Mexico, about twenty miles from the boundary line. I concluded to return to El Paso on the east side of the mountains since the scout, whom I had sent to the principal water holes in the Hueco mountains, reported it impossible for us to survey that mountain range under present conditions.

October 13th.—I returned to El Paso, partly along the foothills, partly in the mountains, and found the observations of yesterday fully confirmed.

October 14th.—I went up along the river side of the Franklin mountains. Very near the city the covering of the granites, etc., by limestone begins, and traces of prospecting can be found now and then, but nowhere the signs of extensive mining. In the dumps and some outcrops, galenitic pieces and pyrites may be easily distinguished, and in passing a limestone quarry worked for the smelter, I noticed an iron bearing streak strongly decomposed, which I would regard as a fair indication of lead.

Returning towards El Paso I took a view of the point of the river which has been proposed for the construction of a dam sixty feet high, to form a reservoir for irrigation of the Rio Grande valley below El Paso. True the mountains on both sides of the river approach to within about 400 feet more or less of each other, and seemingly a rock ledge runs across the river, but a superfiicial estimate shows that instead of costing about a quarter of a million dollars, the preliminary work, material, labor, and the amount to be paid for land to be put under water in the reservoir would certainly require from two to three millions of dollars.

The smelting works located about a mile above Ft. Bliss, work mostly Mexican ores, a good proportion of which are dry ores. The smelter, consequently, needs lead, and here should be a good market for the lead ores of Texas, even if they should prove to run low in precious metals.

The price paid for reduction seems too high although the cheap Mexican labor is counterbalanced by high prices for fuel, and I have no doubt that if the present charges for reduction cannot be lowered, the proprietors and owners of the different lead districts will find it profitable to construct smelting works of their own, even if they have to resort to the primitive Mexican or Catalonian furnace, unless their ores get rich enough in precious metals to counterbalance the heavy expenses accruing after the ores are mined.

October 15th.—I stopped in El Paso, buying provisions and trying to get information at surveyors' offices and from persons thought to be more or less familiar with certain parts of the country.

October 16th.—I started for the Quitman Mountains. In order to find water I had to take the river road towards old Fort Quitman.

The roads in the river bottom are level, but are very heavy (in consequence of deep sand and dust after long continued dry weather), and as the country is crossed by innumerable large and small irrigating ditches I made slow headway. After having passed Socorro I was compelled to make a dry camp on an absolutely grassless plain.

The soil is a rich, alluvial, loamy sand, and the country, where it is settled, is not badly irrigated. The water from the wells in Ysleta and Rivera is strongly alkaline.

October 17th.—The country between Socorro and San Elizario is nearly of the same character as that passed over yesterday, but the soil seems more sandy. There is very little grass, but the land between the road and the river seems to be better timbered. The prevailing vegetation is the Toruajo, with occasional mesquite bushes, and in more sandy and moist places a kind of Epilobium, the Toruajo and the last named forming thickets many miles long and wide.

Below San Elizario I found the river bed dry for many miles. Small holes, dug here and there by Mexican settlers to a depth of five to six feet, held a few pails of salty and strongly alkaline water, and the small pools in deeper places in the river bed were mostly mud, water being so scarce that few cattle can exist in this locality. Outside of some small Mexican villages the country is sparsely settled. I made another dry camp here.

October 18th.—Finding no water in the river and no wells, I made a requisition for supplies at Fabens, which railroad station, although connected by a pump and pipe-line with the river, gets its water supply from water cars.

The soil shows occasionally a little mixture of gravel, but the vegetation undergoes very little change, except that the cacti are more frequent. I made another dry camp.

October 19th.—I started towards Camp Rice. I made a requisition for water at Hancock Station, which is also supplied by water cars.

I reached old Camp Rice only a few minutes before the outbreak of a storm, followed by a severe thunderstorm with rain and hail, and was compelled to take shelter in an empty adobe house with a leaky roof that kept us moving round the room all night to keep dry.

October 20th.—The rain subsided somewhat towards noon, and I started for Fort Quitman. Arriving at Alamo Creek I found it too high to be crossed by the road, but finally found, higher up, a spot which had rock and gravel on the bottom, and there effected a crossing.

The soil along the road near the river is the same loamy sand mentioned above, and becomes mixed with gravel nearer the hills, or mesa, which approaches near to the Rio Grande.

The vegetation changes slowly to a little more grass and fewer shrubs. The cactus species and varieties increased in number and size. Going to camp we had more water than we liked, and had to dig down over twenty inches to find dry spots upon which to spread our blankets.

October 21st.—I started for Fort Quitman. At 11 o'clock we were caught by a waterspout. Fortunately I had espied its approach and escaped being washed away and drowned by hurrying the outfit to a higher spot, round which the water washed from four to five feet deep towards the river.

From this place to a distance of six miles from Fort Quitman, one of my men and I had to wade ahead of the team to make soundings along the road. Arriving at Quitman late in the night we were perfectly exhausted, and finding shelter in the ruins of one of the government buildings, I concluded to rest men and team.

October 22d.—The soil on the road between the last camp and a point six miles from Fort Quitman is a very heavy loam of a more or less dark color; towards the river it is of a more sandy nature, while towards the hills it is mixed with gravel.

The last six miles are mostly on and along a low mesa crossed by numerous watercourses, which are, however, mostly dry, along which are found float pieces from the Quitman Mountains, together with some black sand.

The vegetation towards the river is Toruajo and Epilobium, and close to the river we find cottonwood timber. Cacti grow here in abundance, but very little grass.

October 23rd.—I started toward the Quitman Mountains, and found that the nearer I approached the foothills, the less rain had fallen during the two days previous.

The mesa which I passed before reaching the foothills is composed of a similar conglomerated mass to those along the Franklin range, but they are more frequently crossed by deep and steep ravines.

Traveling along the foothills and the mountains I found float pieces of granite, feldspar, and greenstone porphyries, crystalline limestones, quartz, and quartzites, heavy iron ore, and copper.

Through the gravel deposit of the mesa and the foothills occasional limestone upheavals rise and run into the mountains.

There I found a number of well located and well worked prospects. The "Elbrook," about six miles northeast of Quitman, is located in a contact between crystalline limestone and a granitic porphyry and is sixty-seven feet deep. South of this is the "Mule Mine," which is in a similar contact. Both leads run east and west and dip nearly vertically between well-defined walls. The outcrop is a strongly burned, ferruginous mixture of a siliceous material with heavy spar.

The "Elbrook" carries the galena in a spar gangue, and the prospector claims besides the lead fifty ounces of silver per ton.

Between the "Elbrook" and the west gulch I passed a number of similar contacts on which no claims were located, at least none that are worked or prospected. In the west gulch northwest of the "Elbrook," known as Big Spring Camp Gulch, there are, in addition to many small diggings of a more or less promising character, a number of well defined prospects. Most of these are run down from ferruginous outcroppings in contacts between porphyries, granites, and crystalline limestone. They all run nearly east and west, and dip nearly vertically. Most of these prospects are very promising, and are developed to a depth of from fifty to sixty feet.

The best developed is the "Silver King," worked by a San Antonio company. I found a fair quantity of shipping ore on dumps. This vein runs in limestone. West of the "Silver King" three other less developed but promising prospects are located. The "Emma Clark" mine is a tunnel running zigzag about 150 feet east and west into the mountain; evidently it has not been worked for some time, and is badly ventilated, but I found promising material in the drift, between good walls in the last part of the tunnel, as well as on dumps.

Near by is the shaft of the "Maybell," which is sunk to a depth of about sixty feet. The material of the last few blasts begins to show galena. Of nearly the same character are the "Eureka," "Silver Cloud," and others, which are nameless at present. A new prospect, the "Belle," shows a well defined lead of galena at fifteen feet below the surface. All these prospects are located at an altitude of between 4800 and 4900 feet above the sea level. None of the prospectors have reached water in their shafts, and therefore have to haul their supply from water holes in the Rio Grande. I made a dry camp in this gulch, where I found for the first time since I left El Paso a sufficient supply of grass for the team.

October 24th.—Starting from my camp near the "Maybell," I sent the wagon along the foothills and crossed over the ridge to another gulch, where I found some very faint attempts at prospecting. A tent near a little water hole seems, judging from the outfit, to be the home of ranchmen. This gulch is one of the roughest parts of the Quitman Mountains. The indications for ore, however, are as good as those in the gulches mentioned before, although the outcrop indications are somewhat changed, showing in place of the strongly ferruginous crops decomposed streaks in the porphyritic and granitic country rocks.

Passing down this gulch I met my party on the road to the "Bonanza," the best developed mine in this district. A good road, although very sandy, leads from the foothills to the mine. The lead of the "Bonanza" runs nearly east and west, and dips nearly vertically in a contact between granite and porphyry. A shaft ninety-five feet deep is sunk to a drift running east and west about 350 feet. From this drift a winze is sunk 110 feet deep, which holds at present about nine feet of water, supplying the men and animals at the mine.

Along the road about one and one-half miles below the mine the rocks on both sides of the valley approach each other very closely and offer an excellent opportunity for the construction of a dam at a very low cost. The valley widens above this point, the rise of the ground is very gradual, and the rocks on both sides of the valley seem sound enough to be water-proof.

This valley, which drains a considerable area, would make an excellent reservoir for metallurgical purposes and for irrigation as well.

The shaft opening of the "Bonanza" is about 4850 feet above the sea level.

West of the "Bonanza," and 5300 feet above the sea level, is the "Nickleplate," and southeast of the same the "Alice Ray," "Almina," "Queen Anne," and a copper claim, from which last evidently come the copper floats mentioned above.

The "Alice Ray" claim, at a distance of about 3000 feet from the "Bonanza," runs a tunnel into the same lead. The altitude of the "Alice Ray" is 5095 feet above the sea level. This, compared with the deepest part of the "Bonanza," shows an ore body 450 feet in height by about 4000 feet long.

Both the "Bonanza" and the "Alice Ray" show well defined galena veins running from fractions of an inch up to eight and ten inches in width.

The "Bonanza" claims an average of 30 per cent lead and 30.27 ounces of silver to the ton of shipping ore, and the owners say they have shipped about 500 tons up to date. Good veins are shown in the drift.

The "Alice Ray" had about a car load of ore ready for shipping and a fair show of ore at the breast of the drift on the bottom and roof. The ore of the "Alice Ray" evidently holds some zinc besides the silver and lead.

Besides the shipping ore, I found at both mines a good deal of material on the dumps, which is of too low a grade to stand freight and high reduction rates. It must be concentrated before it can be shipped.

The railroad switch of the Texas and Pacific Railroad is only a few miles from the claims. Near to this lead I noticed another running parallel with it. A number of locations are laid down by monuments, but only slightly worked or not at all.

In this part of the mountains, particularly in the granitic rocks, strongly ferruginous and decomposed outcrops occur nearly at right angles to the contacts, which are entirely overlooked and neglected by prospectors. I think they will show up as favorably as the contacts.

The ores of the copper claim look good enough to warrant the following up of the prospect.

October 25th.—I started from the "Bonanza" and passed out on the east side of the Quitman Mountains. I crossed several quartz outcrops which, although they are very plainly visible and may be traced for more than two miles, seem not to have been noticed as no claims are located on them.

The greenstone porphyries are also entirely neglected although they may be counted among good ore bearing rocks; some of the best gold mines in Transylvania run in this porphyry.

Besides the galena prospects and mines there are very fine copper prospects in the Quitman Monntains, among them the "Hunter," "Crownsnest," "Chief," etc., which claim high assays in gold and silver.

I made a dry camp in the foothills, which here run out in low granitic and porphyritic hills towards the Sierra Blanca.

The Quitman Mountains, rising to an altitude of 6000 to 7000 feet above the sea level, are built up of granite, gneissoid rocks, feldspar, and other porphyries and crystalline metamorphic limestone, and must be pronounced an eminently ore-bearing district.

Its advantages are well defined outcrops and easily noticeable indications, the numerous prospects already opened, and the partly developed mines showing the character of the deeper strata of the gangues, besides which all the gulches are easily accessible and within reasonable distance from the railroad and smelting works.

Among the disadvantages the absence of water is the greatest, but reservoirs can be built at comparatively small expense at many places, and it may be expected that water will be struck in the mines by sinking to a greater depth. Timber is scarce, but the material in which shafts and tunnels must be worked is solid, and requires but little timbering. At present the cedars scattered through the mountains supply the demand for mining timber and firewood.

October 26th.—I started to Sierra Blanca Station, where I took possession of my tent.

The Sierra Blanca Mountains, which I regard as a continuation of the Quitman Mountains, are like them, built up of porphyritic rock, changing locally into granitic material, streaks of gneiss being interspersed with crystalline limestone. Very little prospecting is done in this mountain range, though I found a number of claims located by monuments.

About a mile southwest of the station are some small diggings running in on strongly ferruginous quartzite and iron outblows into a decomposed, rusty gangue, strongly tinged with green and blue carbonates of copper. These prospects are in the contact between the porphyry and the limestone.

The character of these leads as laid open now seems to indicate that they will develop into veins containing both copper and lead.

Some superficial blowpipe tests I made show also silver in the surface material gathered on the dumps.

In the mountains north of Sierra Blanca are many streaks of decomposed rocks with changes of the structure of these rocks, which by and by will be recognized as good outcrop indications.

One of the indications I passed in this mountain range is a more or less iron stained dolomitic spar.

This mountain range, though at present neglected by prospectors, must nevertheless be counted among the ore-bearing districts.

The highest peak of the Sierra Blanca is about ten miles west from the station and reaches a height of over 6000 feet above the sea level.

October 27th.—I laid over at Sierra Blanca Station, attending to office work, selecting, labelling, and packing specimens, and making blowpipe tests.

October 28th.—I walked through the hills south of Sierra Blanca Station. The rocks of which they are composed are in general of the same character as those of the Quitman and Sierra Blanca ranges, and they may be regarded as the connection of the plutonic formations of the Quitman with those of the Eagle Mountains. They are partly capped with limestone, are low and covered by debris and vegetation, and only careful examination can decide whether they are ore-bearing or not. The analogy of the material of which they are built up might lead to favorable conclusions, and they are therefore worthy of being examined more closely.

Water is obtained at Sierra Blanca from the wells bored by the railroad company, as I am informed, to a depth of 2000 feet, and drawn to the surface by powerful pumps. But the Sierra Blanca, like other mountain ranges mentioned before, offers opportunities for dams

and reservoirs for the irrigation of at least a portion of the fertile soil of the extensive plains surrounding Sierra Blanca Station, and for the redemption of this valuable portion of Texas land for farming purposes.

The annexed tables showing the annual and monthly rainfall for the last nine years, and calculations based thereon, will show that this reservoir idea is anything but a chimerical scheme.

October 29th.—I left Sierra Blanca, starting for the Sierra Carrizo.

After traveling the greater part of the day over flat prairie land, the soil of which is a fertile, loamy sand (partly sandy loam), I reached the foothills north of Eagle Flat.

The prevailing grass is gramma, showing that the soil contains lime, and the vegetation of bushes prove its fertile character. Of the cacti, the opuntia and melocacti prevail, while other species of the cactus are more scarce.

The float rock towards the mountains consists of limestone pebbles, with a few talcose, micaslate, and quartz pieces. Sending the team to camp about three miles east of Eagle Flat, I walked to an old shaft pointed out to me four miles north from the railroad station. It is simply a prospect on a copper outcrop, and in its present condition of no value. But it shows that the copper district of the more northern and eastern part of the Carrizo Mountains extends to its most western slopes.

October 30th.—I started to Carrizo Station walking along the foothills north of the Texas and Pacific Railroad. Their limestone capping rests on the crystalline slates, of which I found the float pieces in the prairie. These are exposed in small streaks by denudation in the water-courses, and crossed by small quartz veins, especially where the schists consist of gneiss. As far as the small portions exposed to view show, these schists dip in a southerly direction (about thirty deg.) towards the Eagle Mountains. I took the pass northwest of Carrizo Station. The mountains on the west side of the pass are composed of a trachytic quartzite penetrated and crossed by strongly ferruginous veins which are harder than the older parts of the rock. Outblows of heavy bowlders of this ferruginous mass are frequent on the eastern slope of this mountain.

Across the mountains, I found in a prospect hole, about four feet deep, fair specimens of pyrites of copper in a gangue of gneiss with quartz and feldspar streaks.

The mountains on the eastern side of the pass consist partly of the same rock as on the western side, partly of a conglomeration of smaller and larger bowlders and pebbles of various rocks, held together by a hard, strongly siliceous, and iron-bearing lime cement. Parts of these conglomerates take the form of breccia.

October 31.—I broke camp, as usual, at 6:30, and sent the wagon ahead to the "Hazel" (Clifford) mine. The valley widens northeast of the pass and the steep rough slopes change to more gently sloping hills. The higher steep mountains recede to the background, one to one and a half miles. On the southeast side are located the prospects "Sancho Panza," and "Don Quixote," each represented by a number of shallow diggings on flat pockets in limestone. Green and blue carbonates of copper, with occasionally interspersed pyrites, are found on the dumps, carrying about five per cent of copper. The owner claims besides this, 25 oz. of silver to the ton. About three miles southeast from these prospects a fifty foot shaft is sunk in a well defined lead of black oxide of copper in slaty marls. This lead can be traced several miles nearly north and south. Between the "Don Quixote" and the last mentioned lead I found eight diggings from two to four feet deep, all on pockets in limestone. The material found is invariably the same as in the "Don Quixote" and "Sancho Panza," though seemingly of lower percentage in copper.

Following the lead of black oxide of copper, the shaft of which is said to be on railroad land, for nearly two miles, and ascertaining that it crosses also state land, I recrossed the hills in a northwesterly direction to the foothills of the Sierra Diablo, and walking along the sloping (45 deg.) base of the vertically rising limestone cliffs, which cap a reddish amygdaloid conglomeration of sixty to seventy feet over a base of a uniformly deep red fine grained massive sandstone, without traces of petrifactions, I passed a prospect in a vein of yellowish tinted limespar, not far enough developed to show results. From there to the "Hazel" mine, a distance of about three miles, the country is of a monotonously uniform character. The level of the flats changes to a series of hills of the red sandstone, which rise from 100 to 200 feet above the level of the valley on the north side of the pass.

November 1st.—The "Hazel" mine is located at the foot of the Sierra Diablo, about 5300 feet above the sea level, and the cliffs of the Sierra Diablo rise about 700 feet higher. Above these cliffs the sloping mountains of the Sierra Diablo reach still higher from 200 to 300 feet, gaining in altitude as they run back towards the northeast.

The foot hills on the east side of the Sierra Diablo are composed of the red sandstone mentioned as found on the southern slope, crossed occasionally by limespar leads similar in character to the one on which the "Hazel" mine prospects were located.

There is a great similarity between the limestone capped and amygdaloidal conglomerates over the sandstone, and portions of the copper regions of Lake Superior; and I have

little doubt that the Sierra Carrizo and Diablo next to Llano and surrounding counties will develop into one of the best copper producing districts of the State, perhaps in the United States.

The "Hazel" mine is sunk on a limespar outcrop, and had, close to the surface, pockets of ore running 4000 ounces in silver. The principal ore is copperglanz (or sulphide of copper), at present carrying a good deal of wire silver, and occasional pockets of rich gray copper. This pay streak runs in a vein from a few inches up to two feet wide, more or less, in a gangue of strongly siliceous limestone impregnated with ore. The width of this gangue is thirty-four feet, and the gangue material must be regarded as a low grade ore of about $15 per ton value. The ore of the pay streak averages at present 100 ounces of silver to the ton; of the low grade material, there are several thousand tons on the dumps, which may be utilized if water for concentration can be secured. But although there are some springs close by, and water was struck in the first level of the mine at a depth of 100 feet, this is only sufficient to supply the men and animals and the steam boilers at the mine.

The gangue of the "Hazel" mine runs without wall in the red sandstone, and is at present developed to a depth of 200 feet, with about 500 feet of drift, accessible by two shafts. It is well ventilated and the hoisting, pumping, etc., is done by steam. Judging from the character of the lead of the "Hazel" mine it seems that the rent in the sandstone was infiltrated by watery solutions of the material filling the gangue, and this admits favorable conclusion for other similar gangues in the neighborhood.

The Sierra Diablo with its limestone capping and material above these would require, in consequence of its rough character, months of time to make examinations which would justify a positive opinion, but it seems probable that the sandstone, which appears to be its base throughout its whole extent, is the same as that in which the "Hazel" mine lead runs, and also holds ore-bearing streaks. There is also a marble streak running through this mountain range, the material of which is a fine grained white marble, and which may become very valuable if developed.

November 2nd.—After directing the team to wait for me at the pass, I walked across the hills to the prospect camp of Mr. Osmer, passing on my way a number of prospect holes, part of them seemingly abandoned, part not sufficiently developed for me to judge their merits. Crossing from that camp over a number of trachytic ridges, showing now and then spar-quartz and iron stained streaks, I recrossed to my team and started to Carrizo Station, where I went into camp and prepared a box of specimens for expressage to Austin. The water supply at Carrizo Station is brought in water cars from Van Horn Station.

November 3rd.—I started at the usual time for the Eagle Mountains where I went into camp at the Eagle Springs, now a well sixty feet in depth supplying 600 head of cattle with water. The Eagle Mountains are composed in their northwest part of steep porphyritic rocks of dark color, which on top are partly vertical, rising more than 6000 feet above the sea level. These upheavels meet towards the east a limestone which is partly metamorphic, and partly unchanged, some of which seems not older than the cretaceous. Not quite a mile from the springs is the renowned Eagle Spring coal mine at the foot of the porphyry upheavals. The mine is abandoned and filled with enough water to make it inaccessible. The timbering of the last part of the work, having been too weak, has given way, and part of the digging has caved in. The coal I found on the dumps is for the greater part slate, and the best pieces I selected to build a fire with may, in spite of their good appearance, be regarded worthless as coal.

November 4th.—Hunting up an old Indian trail, along which tradition places large quantities of quicksilver ore in the shape of cinnabar, I followed the sandstone and limestone deposits of a number of gulches and ravines and found them invariably colored brilliantly red by iron. Ascending to a cliff, which, as it is partly scarlet colored, may have been the originator of the cinnabar tale, I found by using my field glass that the scarlet coloring is caused by a moss covering the cliff in patches. The formations admit the existence of quicksilver, but it certainly does not exist where the tradition claims it. Returning through a gulch situated more to the west, I passed a greenish, glassy, volcanic streak, which, higher up in the porphyry mountains, changes into greenstone porphyry, and which decomposes, where it comes in contact with the common porphyry, into a dirty yellowish mass. The so-called coal outcrop of the Eagle Springs mine is duplicated about four miles west of the springs on the foot hills, but has not been prospected at this place.

The springs are nearly 4900 feet above the sea level and the supposed cinnabar cliff, although not the highest point of the Eagle Mountains, is 6109 feet. The limestone east of the porphyry mountains, running out into foothills is covered by a number of strongly iron tinted and decomposed streaks occasionally containing spar, which I regard as being as good indications as those on which some prospects are sunk, one of which shows up a fair falling in of galena in a shallow working. The merits of the so-called silver mine northeast of the springs I think are doubtful, but this prospect may turn out to be a lead mine, in which of course silver is not excluded.

November 5th.—Sending the team ahead, I walked to a southern spur of the Sierra Carrizo that begins about five miles southwest of the railroad station and runs in a northeasterly direction towards the pass between Carrizo Station and Van Horn. The material of these mountains is mostly gneiss, dipping about thirty-five degrees in a southerly direction. It alternates with layers of siliceous slate, talcose slate, and very little clay slate, and is cut by a number of quartz leads which cross the crystalline slates mentioned at an angle of about fifty degrees.

There are a few prospects along the northern slope, the deepest one five feet, in a three-foot quartz lead of a very encouraging character. Farther northeast of Carrizo Station are some prospects in the same country rock, which near the surface show copper stain. Having joined my team, I directed the same to the pass on the road to Van Horn Station, about four miles northeast from Carrizo. This road leads along moderately high hills of the schistose Carrizo rocks. On the southern side near the pass a coarse reddish sandstone runs northwest towards the Sierra Diablo, running into these mountains on the eastern side.

At the eastern end of the pass the gneiss of the Carrizo Mountains disappears under quaternary deposits, and the limestone cliffs, nearly vertical on the north side of the road, recede rapidly to the north.

A low rounded peak near Carrizo Station is composed of the same amygdaloidal conglomerate which rests between the limestone cliffs of the Sierra Diablo, and the red sandstone, in which the pebbles are imbedded, is somewhat coarser.

Although I found no water in the spring supposed to exist in the pass, and a well sixty feet deep close by was also perfectly dry, there seems to be a good deal of moisture in the ground, a coarse bunch grass and willow bushes vouching for water in the ground during the greater part of the year. This pass would be a very good location for a dam to form a large reservoir.

November 6th.—Broke camp at 7 o'clock and started towards Van Horn Station. Walking over the foothills on the western side of the road, I crossed strong outcrops of gneiss through the alluvial soil and limestone float forming these hills and intervening valleys, and well-defined quartz leads may be traced from hill to hill for several miles.

About four miles west of Van Horn there is a prospect located on an iron outcrop. One of the diggings is sunk about ten feet, and judging from the small quantity of material on the dumps, it seems as if some shipments had been made. The other prospect is an open cut in the hillside about four feet wide.

The material of both prospects is partly hematite, partly magnetic ore. Some parts, especially those close to the surface, are strongly siliceous. This prospect seems fully worth working, and will be worked for flux, if for no other purpose, as soon as the development of the prospects in the Carrizo and other mountains justifies and necessitates the erection of more smelters.

Being election day, and one of the polls being at Van Horn, I hurried to that place to vote and because I expected to get valuable information from the people ab ut roads, rocks, and water; but politics being the all-absorbing matter, I was badly disappointed in getting information.

November 7th.—I left the team in camp and started for the Carrizo Mountains, following their eastern boundary.

They consist, on the eastern side, altogether of stratified limestone, bedded on sandstone. The foothills are formed of coarse conglomerates, cemented by calcareous mortar-like material.

There are no distinguishable outcrops of any value on the eastern slope of this mountain range which, beginning three miles northwest of Van Horn, runs in a northeasterly direction for eight or nine miles, ending in a rough pass towards the "Hazel" mine, which, however, in its present condition, can not be traveled by wagon.

The soil north and northeast of Van Horn Station is a fine grained, reddish sand, mixed with limestone gravel towards the mountains, and judging from the vegetation, is tolerably fertile.

All the water to be had at Van Horn comes from the four wells bored by the Texas and Pacific Railroad Company. They are 600 feet deep, and the water is lifted by pumps from the full depth of the wells into the tanks.

November 8th.—I started for a mountain range about ten miles east of Van Horn, known as the Wylie Mountains. They consist partly of crystalline limestone, and deserve a closer examination than I could make under my instructions. I found no prospects there.

November 9th.—I left the team in camp and tramped along the Carrizo Mountains along the railroad southwest of Van Horn Station. This part of the Carrizo Mountains, like that southwest of Carrizo Station, is composed of gneiss and other crystalline schists. Float pieces, as well as some shallow prospect holes, show that in this part of the Carrizo, as well

as in their western and northern parts, the principal metal finds will be of copper, which of course may bear precious metals.

The soil along the foothills is for several miles southward nearly the same as that around Van Horn Station—a red sand, more or less loose, evidently the detritus of the red sandstone mentioned before in the "Hazel" mine district. The only means of utilizing these flats for farming, for which purpose thay are well adapted (aside from want of water), is to irrigate them by reservoirs.

November 10th.—Some rain had fallen last night and we had to dry the tent. I laid in some provisions and fodder, overhauled the wagon, gathered information, and walked along and across the nearer mountains, gathering some float pieces of copper carbonates.

November 11th.—I started for the Van Horn Mountains. Between the station and this mountain range extends a flat, the soil of which for about four miles is the same as that around the station; then it changes to a sand of whitish color, and about two miles farther south it becomes of a more clayey character, the decomposed material of the porphyritic rocks of the Van Horn and Chispa mountains and their foothills (which seems to consist of a metamorphic, strongly siliceous marl) being mixed with the sand. In spite of the dry weather during summer, the growth of grass and of shrub vegetation is rich and guarantees the fertile character of the soil; but farming or stockraising to a greater extent than say 2000 head of cattle without irrigation is out of the question. The Van Horn wells on the old stage road from Fort Davis to El Paso may easily provide water for about 1200 head of cattle, but they are the only source of water in this country.

The bored well of the railroad company at Haskell Station goes down to more than 2000 feet, and supplies only a limited quantity of water, which has to be lifted up by pumps several hundred feet.

The sky being cloudy all day and the weather becoming threatening, I hurried to put up the tent on dry ground and to secure provisions and outfit under roof, which was hardly done before a heavy gale began to blow, and I had to anchor the tent in every direction by guy-ropes.

November 12th.—Short rain showers and a heavy storm-like wind of at least thirty to forty miles velocity lasted all night; but the weather clearing up a little towards morning, I started for the mountains, climbing up northeast from the Wells. The northern and part of the eastern slope of the Van Horn Mountains are composed of the same porphyritic rocks as the Eagle, Sierra Blanca, and Quitman mountains. Feldspar, porphyry, porphyrites, melaphyr, and greenstone porphyry are frequently penetrated by strongly iron-bearing red or yellow tinted decomposed streaks, and in the grass covered foothills these leads can be detected by road-like impressions and the stronger or fresher vegetation.

The high mountains rise a mile from the Wells (which lie 4800 feet above the sea level) to an altitude of from 5800 to 5900 feet. Their slopes are covered with debris and heavy boulders, which hide the rock in places, but at the summit they are more decayed and therefore cut in places, and correspond frequently with the leads in the foothills on both slopes. The descent into a broad valley terminating in limestone hills toward Haskell Station, is equally steep, in the lower part covered by limestone debris and a rich vegetation of gramma grass, sotol, and Spanish dagger, and a kind of small agave. With the exception of a streak on which are found stronger shrubs, including Unguadia (which I regard as a sign of moisture), I found no sign of a spring or water in this very large valley. The ground being covered by grass and shrubs, and the soil evidently resting on a deep layer of debris which is mostly calcareous, I had no hope of seeing any leads. I therefore ascended the next porphyry ridge and followed the valley, which narrows about six or seven miles south of Haskell, to a canon. I trailed the float pieces of granite, gneiss, and quartz to the place of their outcrop. Picking about eighteen inches into strata of hornblende and mica slates between the gneiss, I found them perceptibly impregnated with copper. Higher up in this valley the schists and granite disappear again under crystalline limestones.

In the limestone slopes I noticed some spar leads ten to fifteen inches in width, which may be traced to a considerable distance on both slopes, and which seem worth looking after, as they may mean both lead and copper.

An icy rain and heavy gale prevented my return by the shortest route, so taking a detour out of the valley and round the mountains, I reached the camp shortly before midnight.

November 13th.—I left camp with my team, and going round the mountains to the northeast I found the spurs and foothills to be composed of rocks of a sedimentary character, partly metamorphic. Not having much time to spare, I found no fossils, but saw some traces where they had been on the surface of the strata. Some of these traces seem to be of *Ammonites Bifrons.*

With the exception of iron tinged and decomposed streaks, and some very insignificant spar leads, I found no encouraging outcrops.

The flat between the western slope of the Van Horn and the eastern slope of the Eagle Mountains as far as I touched it, also the flat towards Haskell, is fertile soil, a mixture of the

decomposed porphyries, and, as I saw at an attempted well, about twenty-five feet thick. In spite of excessive dryness during summer it is richly covered with grass and a luxuriant growth of greasewood, yucca, etc. Some of the valleys of the Van Horn Mountains and Eagle Springs seem fully adapted to be dammed for reservoirs, which are here the only means for irrigation or sufficient water supply for larger herds of cattle.

November 14th.—I started afoot southward from the Van Horn wells across the foothills. About four miles from the wells the porphyries join the limestone, which is partly stratified and partly upset in every direction. The slopes are roughly covered by bowlders and debris. They are very steep and between the bowlders a luxuriant growth of grass and bushes proves the fertility of the soil which is the product of the decomposed rocks.

In the deep ravines at the foot of the mountains are small outcrops of a rock which in England is called mountain lime, and which is considered by English miners to be rich in lead ores. I think ore discoveries may be made in this part and further south on the eastern slope of the Van Horn Mountains by more thorough and exhaustive examinations.

The foothills are composed partly of a hard conglomerate of moderate-sized round pieces of limestone, sandstone, porphyries, granites, and quartz, cemented together by a silico-calcareous material. Part of the foothills consist of sandstone.

The alluvial soil of the flat at the foot of the mountains is a rich sandy clay and lime soil. The water-courses are very shallow, never reaching the bottom of the alluvial soil; but judging from the general character of the country, I would take this as well as the other flats to be parts of a former lake bed. The growth of grass is very rich and could feed and fatten thousands of cattle, but there are no springs or water in any shape below the Van Horn wells until the water-holes below Chispa Station are reached, which may supply from 600 to 800 head of cattle, but only under favorable circumstances.

November 15th.—I started towards the Chispa Mountains, keeping along the Van Horn range for about six miles. About eight miles south of the wells the mountains turn more towards the east.

I noticed no peculiar feature even by use of my field glass; and as I will have to pass out of the Chinati Mountains through the Van Horn Pass about fifteen miles south of the wells, I took the road to Chispa station, where I found an opportunity to cross the wire fence of the railroad. The Chispa Mountains are evidently the continuation of the granitic and porphyritic upheavals, which I found and followed mostly through from the Quitman Mountains. They run in a gently sloping ridge, capped with a number of low mountains, into the Apache (Fort Davis) Mountains.

Their appearance shows no peculiarities, and as even their superficial examination would require about three or four days, I passed them for the present, since the meagre information I had about this mountain range proved satisfactorily that they had never attracted the attention of prospectors, and as the absence of water at this time would have made the examination more difficult than it may be at other seasons.

The float pieces were of the same character as along the porphyry ridges of other mountain ranges I had passed, the principal difference being occasional pieces of lava and true melaphyr. The same agate float which I found very frequently in the Van Horn Mountains is also found here and through the greater part of the Apache range, proving the identity of their character.

I went to camp at a water-hole in the prairie four or five miles southeast of Chispa Station and about the same distance from the so-called rim rocks of the Chinati Mountains, or, as this part of them is named, the Capote Mountains.

The soil is covered by good grass, and as there are a number of water holes in the prairie, filled at present, although frequently dry, a herd of about 600 beef cattle and about 100 horses are pasturing in this neighborhood.

November 16th.—I traveled as far as Valentine, where I went to camp near the pump house of the railroad station, the only source of water. Grass is very scant in this neighborhood, and wood still more scarce. The bored well is about 1600 feet deep, and the water has to be lifted by a pump 200 feet to the surface.

The prairie, which extends between the Chinati (Capote) Mountains on the west and the Apache range on the east about twenty-five miles, has good alluvial soil but no water. The spring at the Viejo pass, which I know from former trips in this part, will supply about 1000 head of cattle, disappears in the ground before reaching the prairie. East towards the Muerto range of the Apache Mountains a number of wells are dug at the foot of the mountains. They all supply from a moderate depth (from thirty to forty feet) water for a limited number of cattle, but have nothing to spare for irrigation.

November 17th.—I laid over in Valentine to select and pack specimens and write letters.

The information I got about the Apache Mountains is very scant, referring more to wells and number of cattle than the mountains.

I heard something about some prospects southeast of Muerto peak, and traditions of rich silver discoveries by a ranger, north of Barrel Springs, many years ago.

November 18th.—I started for the Apache Mountains, crossing the prairie east of Valentine, and went to camp northeast of Muerto Springs, in the foothills of the Muerto peak, at the mouth of a valley or break of the mountains, which reaches many miles back to the foot of the so-called Sawtooth Mountains. These mountains, which derive their name from their shape, may be counted among the highest peaks of the Apache Mountains, at least northwest of Fort Davis.

I found water at the well of Mr. Fins' ranch and scanty grass in the foothills.

November 19th.—Leaving the team in camp I started in a southeasterly direction across the foothills, which consist partly of porphyries, partly of conglomerates, and a similar sandstone, though more siliceous and therefore harder, to that at the foot of the Van Horn Mountains, till I reached a deep ravine running in a northeasterly direction towards and between the higher peaks.

The walls of this canon are mostly red porphyry with occasional streaks of melaphyr, above and below which run streaks of ferruginous layers thoroughly decomposed and worth looking after. These streaks dip nearly vertically through the red porphyry, and are evidently younger outblows. Following up the canon I struck a basin of crystalline limestone, opposite Clear Mountain, which extends about a mile southeast from Rock Point.

There are a few faint attempts at prospecting visible, but they merely consist of surface scratchings, one or two feet in depth, or single blasts, probably the work of soldiers on scouting expeditions in these parts of the mountains. They are mostly in perpendicular cliffs and show nothing more than the surfaces themselves, viz: decomposition of rocks.

Near the foot of the Sawtooth Mountains at an altitude of 6070 feet above the sea level, I found some good springs, and about three miles northwest of these in a gulch, a prospect hole worked by an old prospector, on an iron-tinted streak in the porphyry. At a depth of about four feet, between soft talcose, iron-tinged streaks for walls, a lead of feldspathic rock, thoroughly impregnated with pyrites of iron, forms the lead, for which assays of sixteen ounces of silver to the ton are claimed.

One and a half miles northeast from there another prospect is worked for gold in a more quartzose lead. The prospector, who is down about five feet, claims to have specimen assays running as high as $8 per ton.

An old Colorado prospector, whom I sheltered last night, brought me to a strong quartz lead on which he intends to locate. The outcrop is pyrites of iron in quartz, which by a blow-pipe assay I made, shows some silver.

November 20th.—An impenetrable fog covered the mountains and filled the valleys, and in consequence of this I took the old El Paso stage road through the mountains, which leads along and over the foothills to Barrel Springs and the so-called Marble Hills, a ridge of flinty siliceous material, running from 50 to 150 feet high from the well at Ford's range. About three miles from there these hills rise to an altitude of nearly 6500 feet above the sea level, capping the mountains with variously colored, fantastically-shaped rough cliffs.

Crossing and recrossing this ridge at numerous places near Barrel Springs, I ascertained that although different in color from white, yellow, red, gray, purple to nearly black, these rocks are of uniform material or nearly so. I proceeded three miles ahead, where I went to camp near the well of a ranch.

November 21st.—Following up a fairly timbered ravine I came to a very rough cañon leading up between two of the highest cliff-capped mountains, the altitudes of which by barometrical measurement are 6480 feet, and 6670 feet above the sea level. Their slopes run up at an angle of from forty-five to seventy degrees, and are covered with debris and large boulders of the cliffs, which are, like those of Barrel Springs, of various colors.

In spite of the traditions that silver discoveries have been made in this district, I can not regard these rocks as silver-bearing.

The northwest side of these mountains, which is less steep and rough than the others, is well timbered with live oak, Spanish oak, cedar, and pine of considerable size, as are also the smoother places on the southern and eastern sides.

The valleys and lower hills are thickly covered with grass (mostly *buchloe*), and water can be reached by wells at from 30 to 40 feet. I am reliably informed that between the Muerto Springs and Fort Davis about 10,000 head of cattle are pasturing.

November 22d.—I moved on until I came to the so-called "railroad pasture well," where a change in the rocks attracted my attention. In place of a grey porphyritic rock with no indications of metal-bearing leads, a very coarse grained porphyritic granulyte, which decomposes easily, rises on the south side of the road in more rounded hills, strangely contrasting with the trap-like formations some miles west. The contacts between these two kinds of rock deserve closer attention, and I have no doubt that ore discoveries in this part of the Apache Mountains will be made. The north side of the road is fenced off by the railroad pasture, a park-like piece of land, excellently timbered, running up towards the higher mountains, which, by frequent contacts between porphyries and limestone, etc., assumes a promising ore-bearing character.

The water of the railroad pasture well is about 25 feet below the surface and of a very good quality.

November 23d.—I reached Fort Davis. Near to this place the timber becomes more scarce, the mountains along the roads change again to the porphyritic character, and on the south side of the road run out into a flat.

On the north side they maintain the same character to within about eight miles of Fort Davis, where a granitic mountain begins, easily distinguished from afar by its shape. This mountain shows some favorable indications of ore. North of the porphyries and granite mountains, the mountains run out into limestone, and there. to all probability, better outcrops may be expected.

November 24th.—A heavy gale of about twenty-five miles velocity, with cold rain, compelled me to look for dry quarters, which I easily found in one of the many empty houses.

The mountains, rounding on the northern and western sides of Fort Davis, are built up of a trachytic porphyry full of perpendicular rents.

The cliffs, rising perpendicularly from 200 to 300 feet above the level of the post, seem to grow out of a sloping hill (about 45 deg.), covered with bowlders from the cliff, sometimes of the size of a house. These cliffs are very similar to the palisades on the Hudson River. They are crossed by many streaks of decomposed material, some of them strongly iron-tinged and, in spite of the prejudice against the shape of the mountains, I think they might show lead if prospected. Some of these streaks can easily be traced for several miles.

No prospecting has been done in the immediate neighborhood of Fort Davis, but I was shown a number of good-looking specimens, most of which I recognized as being from the Chinati Mountains, but a number of them may, as represented, be found north and east of Fort Davis.

November 25th.—The cold and wet weather keeping on, I decided to rest over Sunday and get information in regard to the next direction in which it might be best to start. Fort Davis is located on the Limpia Creek, a little stream, the source of which is about seven or eight miles west of here. It supplies permanent water in such quantity that it can be used for irrigation of the valley and flat east of the town.

The soil of this flat is excellent farming land, although not richer than that in the valleys and flats mentioned before. The harvests raised on irrigated land along the Limpia show what irrigation would do in the flats west and northeast of the Fort.

The country around Fort Davis, as well as that situated more west and northwest, is also eminently adapted for fruitraising.

The soil in the valleys and flats between El Paso del Norte and Fort Davis is of nearly uniformly good quality. Most of them are better and all at least as well protected against the northers as the El Paso del Norte orchards and vineyards; all that is needed is irrigation. On Gen. Grierson's ranch, peaches are raised equal to the best California fruit, and the grapevines, planted for experiment, are growing luxuriantly.

November 26th.—A number of specimens were brought for inspection, some of which I recognized to be from the southern part of the Chinati Mountains, but there were fair and promising pieces among them reported to be from the spurs of the Apache Mountains running out towards Boracho and Foyah, and from the eastern and southern parts of these mountains. A specimen of copper ore, evidently from a larger vein, with the assay value of 57 per cent of copper and 20 ounces of silver, was represented to have been found in a vein struck in a well 40 feet below surface. I descended into this well and found it dug to its full depth in the same kind of gravel I have mentioned as being found in the other flats. A vein can not be expected in this material.

I found, however, copper float and copper-stained outcrops with the rock in place, and the ore-bearing character of the Apache Mountains in the immediate vicinity of Fort Davis, can not be denied. I think lead and copper will be the first discoveries.

November 27th.—I started toward Marfa. The rocks of the mountains along the road are of the same character as those from Muerto to Fort Davis. Streaks of decomposed material and calcareous streaks, more or less iron-stained, may prove to be good outcrop indications.

The foothills are well covered with grass, but like the flats, destitute of timber, even shrubs. Judging from the float pieces, the rocks seem to run out, at least partly, into limestone. I made a dry camp.

November 28th.—I went to Marfa, the county seat of Presidio County.

The flat between the very gently sloping foothills and the prairie, shows a moderately sandy calcareous loam, evidently fertile and suitable for irrigation, which no doubt can be done by reservoirs. Irrigation by wells is out of the question.

November 29th.—Being Thanksgiving day, and a cold, drizzly rain falling, I laid over. I selected, packed and shipped specimens and attended to mail and office matters. Finding instructions from headquarters at Austin to send a report at once, I started November 30th, to Fort Davis, where I secured, through the kindness of the commander, Col. Cochran, a suitable office, and prepared and finished this journalized report.

As may be seen from this report, I followed the granitic, porphyritic, and crystalline schistose portions of the mountain ranges from Rio Grande, through the Franklin range, through the Quitman, Sierra Blanca, Sierra Carriza, Eagle Spring, Van Horn and Chispa mountains to the Apache range and through part of this, touching the Sierra Diablo and some less important ranges. I selected such slopes as had mines or prospects partly developed and where I could hope to find information and water.

I regard these porphyries as a simultaneous upheaval through their whole extent in Texas and far into Mexico, and I am positive that there is no reasonable cause for going to Mexico to look for minerals in partly worked out mines, since we can find these minerals in fully equal quantity and quality in virgin soil in Texas, provided certain drawbacks, impediments, and prejudices can be removed.

A great number of specimens and prospects which I saw confirm my opinion that most of our Texas prospectors lack experience and persistency. They are familiar only with one or at most with a very few kinds of ores, and the indications and outcrops which have shown favorable results close to the surface in the neighborhood of their proposed prospecting. They look for these same kinds of outcrops and indications in every kind of rock; they can not assay or even estimate the approximate value of ores when found; they mistrust the assayer if he is connected with mines or smelters, and most of them expect to shovel from a five foot digging a bushel of $20 gold pieces and from a ton of rock two tons of silver or gold. Others overestimate the difficulties of developing a prospect, become discouraged and leave their diggings in disgust. Very few experienced prospectors from mining districts from other states are in Texas, as they have at present no inducement to come to our state.

In other mining districts of the United States, the prospector knows that after faithfully putting into the development of his prospect $500 or its equivalent in labor, during the five years fixed by law, he is entitled to a patent and the ownership of his claim. The claims in most of the states are larger (600 by 1500 feet) than in Texas, the mining laws are clear, distinct, and to the point, the surveys in the mining districts start from well established points in the districts, and are not so liable to errors, and there are no doubts about the location of the claim, whether on government or other lands.

The rights of way for roads and water-courses, water rights, the right to use the timber (growing not only on the claim but in the district) for mining purposes, and a number of other privileges and rights are clearly defined and secured to the prospector by the mining laws of the United States.

Here in Texas we have no mining law worth calling such; the surveys of alternate sections are mostly unreliable, title clouds in the shape of Spanish and Mexican land grants and private claims of every description settle over other places, and so on *ad infinitum*. In short, prospectors in Texas, except they work on their own lands, have no protection whatever, and a taxation of five per cent of the gross earnings is high enough to kill a small or only partially developed mine.

The tables of rainfall which I attach to this report are compiled from the records of the United States signal office. They will show, as I said before, that irrigation by reservoirs is not a chimerical scheme, but fully practicable and feasible as every civil engineer must admit.

It is also the only practicable way of making the vast plains and flats of Trans-Pecos Texas valuable land. In spite of its rich soil and excellent climate this country must be regarded as a desert under present circumstances. It needs water even for cattle raising on a scale proportional to its extent.

The few springs and permanent waterholes, which supply a few thousand head of cattle with water, are private property, and their owners control in fact all the superabundance of grass, of which millions of tons decay in the prairies, where thousands of thrifty farmer families might find a comfortable home in an excellently healthful climate, on rich soil, if water for irrigation should be provided.

The boring of artesian wells with an overflow to the surface has proved a failure in these prairies as I predicted years ago that it would. The wells alongside of and in the hills will never supply a sufficient quantity of water for irrigation, to develop this part of Texas and make the land as valuable as it might be made at comparatively very moderate cost by reservoirs constructed by the combined efforts of the state and railroad companies.

Although I confined my observations principally to the economical part of the Geological Survey, which I thought in the spirit of the geological bill, and not contradicting my special instructions, I also took, as far as the hurried expedition permitted, notes on the structural and historical geology, etc. I regard them, however, too fragmentary to base an opinion on until I am through the Chinati and other mountain ranges and their surroundings, which I could not subject to an examination at all, but which are connected with them and may explain phenomena otherwise hard to understand. I reserve therefore such opinion for a final report.

I am sir, your obedient servant,

W. VON STREERUWITZ, C. E., M. E.
Geologist for Western Texas.

RAINFALL FROM 1879 TO 1887 AT FORT DAVIS AND SURROUNDING CIRCLE OF COUNTRY OF 100 MILES DIAMETER.

Year.	Inches.	Date of Heaviest Rainfall During 24 Hours.	Inches.
1879	24.41	October 10	3.14
1880	23.47	July 23	3.01
1881	24.54	August 23	2.16
1882	20.22	September 4	2.10
1883	14.22	July 7 and 8	1.14
1884	22.56	August 25 and 26	3.30
1885	14.22	July 10 and 11	1.23
1886	12.64	September 5 and 6	2.71
1887	18.50	July 16	2.69

Average 19.9, or nearly 345 million gallons to one square mile.

AVERAGE ANNUAL RAINFALL BY MONTHS.

Month.	Inches.
January	0.517
February	0.240
March	0.490
April	0.540
May	1.380
June	2.250
July	3.210
August	4.740
September	2.490
October	1.920
November	0.490
December	0.330

NORMAL AVERAGE TEMPERATURE IN WEST TEXAS.

Month.	Degrees.	Remarks.
January	43.0	
February	48.3	
March	54.6	
April	63.0	Time for rainfall.
May	67.3	
June	75.4	
July	75.2	
August	71.8	
September	67.2	
October	66.6	
November	50.6	
December	45.0	
Annual average	60.66	

The rainfall in El Paso and in the districts along the Rio Grande is considerably heavier than in the district this side of the Quitman and Eagle mountains and Franklin Range. The Fort Davis average holds good anywhere in the country which I have passed through to date.

REPORT OF GEOLOGIST FOR NORTHERN TEXAS.

Mr. E. T. Dumble, State Geologist, Austin, Texas:

DEAR SIR—In compliance with your request, I have the honor to submit a brief report of my geological observations in the northern part of the state, to which work I was assigned by yourself on the first day of last October.

I at once began preparations for the trip, and on the 15th of the same month was in the field at work. Since that time I have been continuously in the field, devoting all the time possible to making observations in the Carboniferous formation, except one week spent in going over the line of the Texas and Pacific Railroad on a tour of observation as far west as the Pecos River.

During the progress of the survey I have collected samples of the rocks, ores, and other minerals and soils, as well as the fossils occurring in the formation. I also collected from various sources such meteorological facts as it was possible to obtain, and noted the trees and plants and other indications of the agricultural resources of the region visited.

In making this general survey over so wide an area in so short a time it was impossible to trace out all the localities of rocks, ores, and coal, and to determine the exact areas occupied by them, or to estimate the amount of each in the space it occupied; yet these explorations, besides giving a general view of the country, have prepared the way for making a more detailed examination.

I have confined my observations to that part of the state north of the line of the Texas and Pacific Railroad, or very nearly so, and east of the Pecos River.

In this district there occurs the Quaternary, Tertiary, Jurassic, Triassic, Permian, and Carboniferous formations. Of these the Carboniferous is the only one of which I can speak at this time.

CARBONIFEROUS FORMATION.

The Carboniferous formation in this part of the state embraces only the Carboniferous and Permian periods. I am aware of the fact that the sub-Carboniferous period has been reported from Erath and Palo Pinto counties, but I have seen nothing to warrant such a conclusion; in fact, the evidences are all against it, and I do not believe it exists. Only the upper and lower Coal-measures, with the Permian above are found in this part of the state. As I intend to discuss the Permian at another time, and under a different caption, the following remarks refer only to the strata of the Carboniferous period, and I shall not in this report attempt to separate the strata into upper and lower Coal-measures or epochs.

This formation is situated between the Cretaceous on the east and the Permian on the west. The eastern boundary between the Carboniferous and Cretaceous formations begins at a point on Red River near the northeast corner of Montague County, running thence past Decatur, in Wise County, to Millsap, on the line of the Texas and Pacific Railroad, and thence in a southwestern direction to the Colorado River.

The line between the Carboniferous and Permian formations on the west begins at a point on Red River, near the northwest corner of Montague County; thence by a line passing Buffalo Springs, the southwest corner of Archer County, through Throckmorton County to Baird, and thence in a southwestern direction to the Colorado River.

The Carboniferous strata, as I have observed them, are about 2000 feet thick. The country is generally quite broken, consisting of high hills, with deep valleys of erosion between them. Some of these hills are 250 feet high, and the country has a rapid ascent to the northwest.

The country is generally overgrown with post oak, black jack, elm, pecan, hackberry, and mesquite, and in places there are groves of live oak. Along the creeks and rivers, in addition to the timber already mentioned, we find walnut and cottonwood.

DIP OF THE STRATA.

In some states the coal measures dip at various angles, forming what are sometimes called "coal basins," and both sides or edges of the strata are exposed. Such is not the case in this part of Texas. The lowest strata are seen on the southeast, from thence there is a gradual ascent to the westward, exposing one stratum after another up to the top of the series, where they pass under the Permian formation, and their western edge is therefore not exposed at all. The dip of the strata is to the northwestward, and it is therefore useless to expect to find such coal basins as I have mentioned above in the Carboniferous of this portion of Texas. The dip of the strata is about thirty feet to the mile, and the average ascent per mile from Millsap to Cisco is ten feet.

COAL.

No connected scientific observations or examination has heretofore been made to determine the number of coal seams in the formation, their thickness or extent. The finding and developing of mines has been more a matter of accident than otherwise, though enough money and labor has been expended in prospecting for coal in Texas, that has been absolutely barren of results, to have made a complete geological survey of the whole Carboniferous formation in the State.

There is a popular notion that where a thin seam of coal is found there will be another and a much thicker and better one found below at no very great distance. A more fallacious notion does not exist, nor one that is so self-evidently false. The only way by which the probable thickness of a seam of coal can be determined and its relative position to other seams in the series known is by making just such a section of the whole formation as I have here attempted.

Another popular notion exists that is as equally incorrect, and that is, that by following a seam from the outcrop under some hill near by, the coal will become much thicker and of better quality. It must be remembered that the coal seams were made long before the hills were formed by the erosion of valleys between them, and that the seam of coal formed a single stratum extending under considerable territory, before the valleys were cut through it. The coal seam had nothing to do with the making of the hill, and the forces making the hills did not affect the thickness of the seam in the hill. The hills have not been made by upheaval in this part of the state, so there is no reason to suppose the seam of coal will be thicker under the hill than at the outcrop. There is always great persistency in the thickness of coal seams that are as nearly horizontal as they are here. If there is a slight parting of clay or slate in the coal seam it will generally be found in it throughout the entire extent of the seam. It is often miles from the outcrop of a seam before there will be any permanent change in the thickness, and then it is just as liable to become thinner as it is to get thicker. The coal at an outcrop, where it has been exposed to atmospheric influences, is, however, more liable to be impregnated with impurities than where it has been protected from such influences.

THE EXTENT OF THE COAL FIELDS.

As will be seen by reference to a previous paragraph in this report, the Carboniferous formation or true Coal-measures in the state embraces the following counties and parts of counties. In all of these there are outcroppings of coal, and when a complete and full geological examination of the state has been made, so that prospecting can be done under scientific direction, there is no doubt but good workable seams of coal will be found in each of them. The counties embraced in the true Coal-measures are (so far as the present examination shows) Montague, Jack, Young, Palo Pinto. Eastland, Stephens, and Coleman, and parts of Brown, Runnels, Callahan, Wise, and Erath.

In the general section of the strata I show nine seams of coal. Only two of these, however, are thick enough, where observed, to have any commercial value. These seams range in thickness from two to thirty inches. The fact that some of these seams are very thin is no reason to conclude that at some other locality remote from the place first observed they may not become of sufficient thickness to be of commercial value.

There may also be other seams of coal in the strata than those indicated, that will be discovered upon further investigation, that were so thin or were so entirely covered up as to escape my notice.

Each of these seams must be studied in connection with the fossils that are in immediate association with it. The lithological character of the associated strata must become so well known that the coal seams can be distinguished wherever they may be seen. Very often the rocks and clays in different parts of the strata are so nearly alike that from their general appearance they can not be distinguished, while it may readily be done by knowing the fossils associated with each. When the study of the formation has progressed far enough to enable the scientist to recognize the different members of the group of strata wherever found, there will be no trouble in giving correct information on the value of coal seams, and to direct prospecting for coal in a given locality successfully, where it is possible to obtain coal, and to discourage the expenditure of money in sinking shafts for coal where there is no possibility of finding it.

I will give a brief description of these coal seams as they appear at the locality where each was examined, and in the same connection will give a statement of the mines located on the veins.

Coal seam No. 2 is a thin seam two inches thick, situated ninety-seven feet above No. 1, as observed at Millsap, and is about similarly located in reference to seam No. 1 wherever seen. This seam does not appear to change much in thickness, and is probably of no economical value.

Coal seam No. 1 was first seen on this trip at the old mine of Carson and Lewis, about four miles north of the town of Millsap. It was also seen at Gordon and at the Johnson mine in Erath County. This seam ranges in thickness from eighteen to thirty inches. It has a thin parting of slate about the middle of the seam, never over one-half inch thick, and generally much less. In the vicinity of Millsap this seam crops out in a number of places on both sides of Rock Creek. A good deal of prospecting has been done in the vicinity, and quite an amount of coal was taken out at the Lake mine, and also at the Carson and Lewis mine.

LAKE MINE.

The Lake mine was developed and worked a few years ago by Mr. W. F. Lake, of Fort Worth. The seam was found to be from eighteen to twenty-six inches thick, with a slight dip to the northwest. It was developed by driving a working shaft into the side of the hills on both sides of a hollow, following the seam of coal. The seam at the mouth of the tunnel is about fifty feet above the bed of Rock Creek. The coal taken out was hauled in wagons to Millsap and disposed of to the Texas and Pacific Railroad and used by them for running the locomotives on their road. It was pronounced by their engineers to be a very fair quality of coal for their purposes. There was no water in the mine when it was being worked. The timber for props and other purposes was obtained in the vicinity of the mine. The work on the mine was discontinued principally for the reason that it would not pay, owing to the thinness of the seam and the cost of mining and transportation.

CARSON AND LEWIS MINE.

The Carson and Lewis mine is situated one mile north of the Lake mine, and is on the same seam of coal—No. 1. This mine was opened and worked in 1884. The seam at this place is about twenty feet below the bed of Dry Creek, a tributary of Rock Creek. The mine was developed by putting in an incline to the coal. The coal mined was hauled to Weatherford and used in the furnaces of the Parker County Flouring Mills. The work was discontinued for the reason that it would not pay to haul the coal overland in wagons to find a market. The surroundings are about the same as at the Lake mine.

The following is a list of fossils found in the strata surrounding this seam of coal, viz.:

Nuculina bellistriata,
Pleurotomaria sphaerulata,
Spirifer umbonatus,
Spirifer lineatus,
Chonetes mesoloba,
Myalina subquadrata,
Bellerophon sp. Aviculapecten occidentalis,
Pleurotomaria carbonarius,
Productus costatus,
Discina convexa.

In the mines mentioned above there was no water encountered in mining except such as came in from the surface. Plenty of timber can be had from the surrounding country for all timbers necessary to be used in mining.

The following is a section of the strata as it is found in connection with this seam of coal:

No.	Top.	Feet.	Inches.
1	Conglomerate	6	
2	Sandstone	4	
3	Bluish clay	5	
4	Coal Seam No. 2		2
5	Yellow and bluish clay	60	
6	Yellow clay	7	
7	Slate	20	
8	Coal Seam No. 1		18
9	Fire clay		6
10	Bluish clay	25	
11	Thin-bedded sandstone	4	
12	Yellowish clay	75	

GORDON COAL MINE

This mine is also on Seam No. 1, and is situated about four miles northeast of the town of Gordon, in Palo Pinto County. At this place several years ago considerable coal was taken out. The Texas and Pacific Railroad built a spur to the mine, and the place gave promise of being of some importance. A short time spent in examining the locality con-

vinced me that the mine had not been well located, as the coal at this locality had been too much exposed to atmospheric influences. The mine was worked by three tunnels driven into the western sides of the hills on the seam at the height of about fifty feet from the base. One of the tunnels was driven entirely through the hill. I traced the seam of coal in this vicinity, from where it first appears at the junction of the spur of the railroad with the main line, several miles northeast of the mines. The dip is to the northwest. I did not go into the mine as there had been a fall in the roof and it was not considered safe to do so. The seam here is from twenty-six to thirty inches thick with two thin partings of slate seldom more than one-half an inch thick. The coal has a large percentage of sulphur in it and in burning made a great amount of clinkers. The coal mined here was mostly used by the Texas and Pacific Railroad in their locomotives. There was a great deal of complaint among the engineers about the poor quality of the coal. I am of the opinion that a better place can be selected for working this seam in this locality; one where the coal has not been so much subjected to atmospheric influences, and consequently will not be so highly impregnated with the sulphuret of iron.

The following section was made of the strata at the Gordon coal mine:

No.	Top.	Feet.	Inches.
1	Conglomerate	20	
2	Sandstone	4	
3	Clay	8	
4	Coal Seam No. 2		1
5	Shale with clay ironstone	30	
6	Sandstone	5	
7	Shales	30	
8	Coal Seam No. 1		30
9	Fire clay		8
10	Bluish shale	45	
11	Shell concretion, *productus*, *myalina*, *athyris*, etc	1	
12	Shales	10	
13	Limestone buff		18
14	Shales, bottom not seen		

JOHNSON COAL MINE.

This mine is also located on Seam No. 1, and is situated about two miles south of the line of the Texas and Pacific Railroad at about equal distance between Gordon and Strawn. The mine is worked by two shafts, about one-fourth of a mile apart. The shafts are known as No. 1 and No. 2. There are numerous outcrops of the coal in this vicinity, probably more than at any other place. I traced the outcrop for several miles to the south and west. To the north and east of the mine the seam has been entirely destroyed by erosion. In this vicinity there has been a considerable bending of the strata upward giving to the seam a dip to the southwest, but this dip is merely local and does not extend very far, and in the distance of a mile or two the strata resume the general dip of the country to the northwest. The seam is thirty inches thick with a very thin parting of slate. There is no hope that this parting will entirely disappear. It is seen at every place where this seam of coal has been exposed. The roof over the seam is very good. It is slate with a very few slips. The mine is worked by the long wall system. All the coal is taken out and the strata above is permitted to sink down as the mining advances. There is no water in the mine nor has there been gas of any kind. The timber for props is obtained in the vicinity. The mine has now been in operation for two years and has a producing capacity of about 400 tons per day. There is a spur built from the main line of the Texas and Pacific Railroad to the mine, and the coal mined is taken away each day and used by the railroad in their locomotives on the western division. When properly mined, the coal is spoken of by the engineers as being of very fair quality. The mine is on the north end of the Pedro Herrera survey of 2300 acres. Prospecting shafts have been sunk on several parts of the survey and the coal was found in all of them of about the same quantity and quality as at the mine.

THE PALO PINTO COAL MINE.

This mine is also on seam No. 1, and is situated about one and one-half miles southeast of the Johnson mine. The shaft is near the western base of the mountain and is about forty feet deep. The coal taken out is similar to that of the Johnson mine. The covering is good and what was said of the Johnson mine may be repeated of this. The spur of the Texas and

Pacific Railroad running to the Johnson mine has been extended to this mine also. The capacity of the mine is about 300 tons per day, and can be easily increased to 500 per day. The property embraces about 2000 acres, and it is the intention of the owners to work this mine to its fullest capacity. They find sale for the coal in Fort Worth, Dallas, and other cities in the state. In Dallas it is put on the market at a lower price than the coal from the Indian Territory.

It will be observed that all these mines are located on seam No. 1 of the general section, and although they are in the extreme 30 miles apart, it is not hard to identify the seam as being the same at all of them, and I think it possible to trace this seam from hill to hill by its outcrop the entire distance. This seam is the lowest one exposed in the country, and there is no reliable information of the existence of another seam below. Parties in different localities, acting upon the popular notion of the existence of a second seam, have gone to the expense of sinking shafts hundreds of feet below the horizon of seam No. 1 without finding coal. It may also safely be said that there is no coal southeast of the outcrop of seam No. 1.

COAL SEAMS NO. 3, NO. 4, NO. 5, AND NO. 6.

These are all very thin seams and for the present are of no commercial importance where observed. They occur between Strawn and Ranger on the line of the Texas and Pacific Railroad. I went twelve miles north of Strawn to examine a seam of coal and found an outcrop 18 inches thick. I did not have time to determine to which of these seams it belonged, but it can be easily identified upon proper investigation.

COAL MINE AT CISCO.

The mines at Cisco are on seam No. 7. At one time and another there has been considerable work done on this seam in the vicinity of Cisco. The outcrops are numerous. The seam at this place is 20 inches thick, with a band of slate above it followed by a seam of coal four inches thick. The band of slate is from 4 to 10 inches thick between the coal seams. At another place where I examined this seam there was 9 inches of coal and 20 inches of bituminous shale.

This shale will burn when put on the fire but looses none of its bulk in burning and is absolutely worthless as a fuel. There is no probability that this seam can be worked in this particular locality owing to the thinness of the seam and the further fact that the stratum of bituminous shale will have to be taken out of the mine, for it is so highly impregnated with sulphuret of iron, that when the matierial is exposed to the atmosphere and it begins to slack, the sulphuric acid escaping will set the whole mass on fire. The seam may become thicker at some distant locality, but there is no hope that it will change for the better any where near Cisco. Four miles from Cisco to the northwest, on the line of the Houston and Texas Central Railroad, this same seam of coal was found about the level of Sandy Creek. A good deal of work was done at this place several years ago, but the mine has been abandoned on account of the fact that the seam was too thin for successful mining. Attempts have been made to develop this seam in several other places with like results.

I have now traced this seam to a point sixteen miles north of Cisco and have always found about the same state of facts to exist. A short distance above seam No. 7 there is a thin seam, only two inches thick, that I have not included in my general section, and that is of no commercial value. This seam I will call No. 8.

Seam No. 9 is a thin seam seen three miles east of Putnam, but was not followed nor investigated sufficiently to give any particular description of it.

There are two other mines I have visited, but they were so distant from my base of operations and my time was so limited that I was unable to determine definitely to what horizon they belonged.

THE DECATUR MINE.

Ten miles west of Decatur, in Wise County, near the west fork of the Trinity River, there is a seam of coal outcropping in the bed of a branch. I have provisionally put this with seam No. 1. A few years ago a mining company was formed at Decatur for the purpose of prospecting and developing this coal. They did a large amount of prospecting by sinking shafts and did some mining by driving a tunnel into the hill along the seam near the outcrop. The coal taken out was hauled in wagons to Decatur and disposed of to the citizens for domestic and other purposes. The seam is thirty inches thick and of good quality. It is the freest from partings of clay and slate of any coal I have seen in the state. The covering is good, it is free from water and gas, and there is a plentiful supply of timber in the vicinity for all necessary mining purposes. The seam can be worked profitably as soon as there is a railroad in the vicinity to give transportation for the coal. The mine is kept open and coal enough taken out to supply the local demand. The seam has been prospected over several thousand acres of land and found to be about the same in all places.

THE STEPHENS COAL MINE.

This mine is situated about four miles west of Bowie, in Montague County, and is owned by Hon. John H. Stephens, of Montague. The coal seam is three feet thick, with a parting of clay three inches thick. The first work done on the seam was the driving of a tunnel 300 feet long on the seam into the side of the hill. Then a shaft was put down on the opposite side of the hill, where the coal was reached at a depth of fifty feet. Here there was considerable water in a stratum above the coal. Another shaft was put down one-half mile still further north and the seam reached at a depth of ninety feet. The coal at this shaft was better than at either of the other places. In a stratum of sandstone above the coal a considerable amount of water was found, and for want of suitable pumping apparatus very little was done in the way of taking out coal. Proper prospecting at this place will no doubt develop a good workable bed of coal. I have been unable to place this seam of coal in the general section. It is evi ently higher than seam No. 1. Further investigation will no doubt enable me to put it in its proper place.

From my recent observations I am enabled to say that there are two distinct horizons where the seams of coal are thick enough to work. I find one seam above the massive limestone and one below it. Seam No. 1 is below and seam No. 7 is above. The Stephens coal seam is also above the limestone.

I have now given a brief statement of the various coal seams as I have found them. My next work will be to go through the counties of Stephens, Young, Jack, and Wise as rapidly as possible and examine the various out croppings of coal, which are said to be quite numerous in these counties, and at the earliest moment possible furnish you with a report of my further investigations.

ECONOMIC MINERALS.

Iron Ore.—Loose masses of iron ore are occasionally seen among the debris washed down from the hills and scattered over the surface of the country in various localities in the Carboniferous formation. It was seen only in a few places, under circumstances indicating beds of even limited extent. Near Gordon, in Palo Pinto County, I obtained some fine samples, but my facilities for examining the bed were not sufficient to enable me to form an opinion as to its extent nor the probable amount of ore that could be obtained. In the southern part of Stephens County, where we are now camped, there appears to be a good deal of ore, judging of the deposit by the amount that is scattered over the surface.

Building Stone.—The building stone of the Carboniferous formation comes from both the limestone and sandstone beds. The United States Court House in Dallas is built of a gray sandstone taken from a quarry near the Brazos River, on the line of the Texas and Pacific Railroad. The stone is smooth, even-grained, easily worked when first taken out, and hardens on exposure. It is compact and even-grained enough to make good grindstones. In fact this bed of sandstone, at another locality, has been used to a considerable extent for this very purpose. The grindstones made of it are said to be of a superior quality. The stone at this quarry can be obtained in unlimited quantities and of as large dimensions as can be used in the erection of buildings. The stone is quarried near the railroad and loaded directly on the cars for transportation.

There are several places near this quarry where this bed of stone is exposed, and where excellent quarries might be developed. This is the nearest good building stone to the cities of Dallas and Fort Worth. that can be conveniently obtained, and it is only a question of time when large amounts of it will be used in these cities. Several large buildings in the cities named have already been constructed of this material.

At Ranger another quarry of sandstone has heen opened and a large amount of stone taken out. This quarry is about half a mile from the main line of the Texas and Pacific Railroad. A spur has been built from the main line to the quarry and it is as convenient to ship the stone as if situated on the main line of the railroad.

All the public buildings in this region are built of this sandstone, and in all the towns the stone has been used in the erection of private residences and business houses. The limestones are also of sufficient firmness in many localities to make good building material. This is more frequently the case in the upper part of the strata than in the lower portion, and the western limestones are better for building purposes than are the eastern, in the Carboniferous of Texas. There are three different colors of these limestones in the formation, the gray, buff, and blue. Each of these takes a fine polish, is free from flaws, and compact enough to stand a heavy pressure. They all resist atmospheric influences admirably.

The limestone has been used in some of the western towns to a considerable extent in the erection of buildings, both public and private. The court house in Jacksboro is built of blue limestone, as is that in Albany and Seymour and other county towns in this part of the state.

There is a thin bed of limestone at the Brazos River, on the line of the Texas and Pacific

Railroad (No. 103 of the general secti ns), that is very hard and compact, breaking with sharp corners. This material is being used in Dallas for macadamizing the streets. It is near the surface and is quarried and loaded on the cars at $5 per car.

Clays.—Brick clay is as common in the Carboniferous formation as sand. These clays may be obtained in almost any locality. Many of them are mixed with iron, and will make the finest of bricks. These bricks burn red, and are of such permanent color that time will have little effect upon their appearance. The fire clays are also abundant, and are to be found in connection with all our coal beds. These will all be developed when the demand for such material is sufficient.

Lime.—Almost any of the limestones belonging to the Carboniferous formation will make good quick lime. The local demand for building purposes has been cheaply supplied by erecting kilns in the vicinity of the place where the lime was to be used. These old kilns are to be found near every town I have visited. The lime is said by the masons who have used it to be of excellent quality. The lime has some alumina or earthy matter mixed with it, which adds greatly to its value for builders' use.

Conglomerate—This conglomerate is seen everywhere on top of the different strata of the Carboniferous. As I refer to my notes I find it on every hill of which I make mention. No matter what part of the strata is exposed on the hills, on top of it will be found this bed of conglomerate. It varies in thickness from a foot or two to twenty-five feet. It is composed of siliceous pebbles and sand Sometimes the gravels are very coarse, and at other times are quite small. They are very much water-worn. Sometimes these pebbles are bound together in a ferruginous matrix, and at other times by silica. In places it is very much decomposed, making large deposits or beds of sand and gravel. I have traced this conglomerate from the Canadian River on the north to the Colorado River on the south, and I have never seen anything on top of it, nor do I remember ever to have seen it resting upon anything except the Carboniferous formation. There are no fossils of any kind found in it, but I have often found pieces of petrified wood in the beds of sand and gravel formed from the conglomerate, although I have never been satisfied that they come from the conglomerate. These pieces of petrified wood are nearly all exogenous.

In the general section of the Carboniferous I have put this bed on top, yet I am not sure that it belongs to the Carboniferous. I am of the opinion that it does not. All I now know about it is that it is on top of my entire section of the Carboniferous of over 2000 feet, and that there is scarcely a single stratum of the whole 103 that goes to make up the general section upon which it does not directly rest. For the present I do not care to theorize upon it.

Gravel.—The question of having dirt roads that will be passable in winter and spring during the rainy season has become one of considerable importance in some of the counties embraced within the "black waxy land" district. In Dallas County public meetings have been held by the citizens to devise ways and means for constructing passable roads through the county. In that county it has become a matter of absolute necessity. One of the questions to be considered is the material out of which to construct these roads. It is worse than useless to attempt to use the white limestone of that district to macadamize the roads, owing to the fact that it decomposes very rapidly when exposed to the atmosphere. There are indeed no hard rocks in the black land counties out of which roads can be built.

There are, however, extensive gravel beds in many places in the country occupied by the Carboniferous formation, made from the conglomerate bed overlaying it, that would furnish just the material needed. Of course the question of transportation will have to be taken into account, but certainly no better material could be found for road making than this siliceous gravel. Dallas City is now shipping large quantities of limestone from this district with which to macadamize her streets. It costs $5 per car to quarry and load the limestone, and it ought not to cost any more to load a car with gravel. There is an abundant supply of material here for any demand if it can be made available.

MINERAL WATERS.

There are quite a number of places in the Carboniferous formation where the water is highly impregnated with minerals of different kinds and in different quantities. Nothing, however, can be determined as to the medicinal qualities of these waters without a very close analysis. No time has been taken to collect these waters on the present expedition, as it was found impracticable to do so.

One of the most noted places for mineral water is at Mineral Wells, in Palo Pinto County. The water here is reached at a depth of eighty feet, passing most of the way through a bluish clay into a sandstone. The stone in which the water is found is probably the equivalent of No. 92 of the general section of the formation. Many invalids visit these wells every year and derive great benefit from the use of the waters.

NATURAL GAS.

The natural gas of the Carboniferous formation in Texas has not been sufficiently developed to determine its economical value or importance. I know of no examination having been made of it outside of what I have been able to make on this expedition, which has not been sufficient to enable me to reach a definite conclusion.

Gas has been found in several places by mere accident in boring for water or prospecting for coal, and when so found no further attention has been given to the matter. No effort has been made to determine the extent of the field in which it exists nor the probable quantity at any given locality. At Gordon, in Palo Pinto County, a flow of gas was found at a depth of 370 feet. A beer keg has been turned over the well and a tube with a burner attached inserted, and every night the town is lighted by this one lamp.

One mile east of Gordon another well was put down and at about the same depth the gas was found, but no effort has been made to utilize it. From each of these wells there is a small flow of salt water. The gas is odorless.

In prospecting for coal four miles from Strawn southwest, a flow of salt water was found, and with it a flow of gas, but no effort has been made to test the quantity.

Four miles northeast of Cisco there is a flowing well, the water of which is highly impregnated with salts and which gives off quite an amount of gas.

It is very probable that a sufficient amount of gas can be obtained at these salt wells to run all the machinery necessary for the evaporation of the waters.

SOILS.

In my examinations of this district of country I have given particular attention to the soils. I have been guided in what I shall say about the soils by their physical properties, the rocks from which they are derived, the plants and trees which grow upon them. A vast amount of work will have to be done in the laboratory before we can deduce conclusions so definite and positive as to give practical cultivators the most valuable and legitimate fruits of the survey. As no analysis of the soils has yet been made, it will be absolutely impossible to speak with certainty respecting some of them. The soils derived from the various formations are very materially different, and even those derived from the same formations do not always have the same properties.

In the bounds of the Carboniferous formation there are four different kinds of soil: First, the river bottom lands; second, lands along the smaller streams; third, prairie lands; fourth, lands of the high plateaus, on top of the highest hills and ridges.

The main Brazos River runs through the entire formation from northwest to southeast. The Clear Fork of the Brazos, one of its principal tributaries, flows through part of Shackelford and part of Stephens and Young counties, forming a junction with the main river a few miles south of Graham. The river is very crooked, and owing to this fact there are hundreds of miles of river frontage in the boundaries of the Carboniferous formation. Both these rivers have their source at the foot of the Staked Plains, and flow across the great gypsum fields of the west, bringing down and depositing large amounts of the clays, gypsum, and sands of that formation on the broad bottoms along their entire course. These river bottom soils are very deep and are generally of the same character throughout. The only change in the character of the soil is where material has been washed down from the adjacent hills and spread out over the broad valleys. The soil is known as red sandy loam. The native growth of timber is elm, hackberry, pecan, walnut, willow, and cottonwood. This growth is confined to the margin of the stream. Generally the broad valleys are covered with a thick growth of mesquite, with here and there a grove of wild china. The principal wild or native grass on these valleys is the mesquite. Sunflowers grow luxuriantly on such places as are destitute of grass. The broom weed grows everywhere and on all kinds of soil. The crops grown on these lands are corn, wheat, oats, and cotton. Vegetables of many kinds are abundant. There are no better lands in the State of Texas than the valleys of the Upper Brazos.

The second class of soils are those found along the creeks and branches. These soils are formed from the decomposition and washing down of the rocks and clays of the surrounding country. They vary in character very much and that within short distances, owing to the difference of the strata in the surrounding hills. The soils are of various colors, red, chocolate, gray, and black. All of them are very fertile and are easily cultivated. The principal crops are corn, wheat, oats, and cotton. They stand drouth much better than any other lands in the country. The timber is more abundant and of greater variety than along the rivers, and there is generally more underbrush than in the river bottoms. The soils are all called sandy, and many of them have a good deal of vegetable matter in their composition. The soil changes color, and of course composition, sometimes every few inches in depth. The subsoils are as variable as are the soils on top. Some of the best farms in the country are situated upon this class of soil.

The third variety of soil in this district is known as the prairie lands. These soils vary very much in color and composition. They range from the light colored mesquite lands to the heavy black "hog wallow." Some of them are reddish. While these lands are called prairie, they very often are covered with a thick growth of mesquite, and some of them in addition to the mesquite, have here and there a post oak or live oak tree. These black "hog wallow" lands resemble in appearance very much the "black waxy" land of Northern Texas, but these all have considerable sand in them, which is not the case with the lands in the northern part of the state. These soils produce fine mesquite and other grasses. The grass on these lands is not easily killed out by the stock running over it, as is the case with the lighter and more sandy soils. As a consequence it is a favorite land with the stockraiser in this section. It ranges from six inches to two feet thick, with a subsoil of various kinds. It is better for wheat and oats than for corn and cotton, yet good crops of these are produced upon it under favorable circumstances.

I do not intend to include in this description the prairies west of the "Upper Cross Timbers," which will appear under the description of the Permian formation, where they rightfully belong.

The fourth variety of soils are the sandy soils found on top of the high plateaus, hills, and ridges. This class of soil has received very little of its material from the Carboniferous strata, but was mostly derived from the decomposition of the stratum of conglomerate overlying it, and by the material brought from some other locality than the Carboniferous by the floods which broke up and washed away the material in the formation of the present hollows, valleys, and river channels. I have not made sufficient examinations to determine just when that time of erosion was with certainty, but now think I am safe in saying it was post-Tertiary.

These soils are from a few inches to two feet thick, and where they are largely derived from the decomposition of the conglomerate are very sandy. The subsoil is often a reddish clay. On this soil is generally a thick growth of post oak and black jack of small size. In wet seasons this soil will produce good crops, but it will not stand much of a drouth. It will be admirable for grapes and other kinds of fruit growing. I saw but few farms on this kind of land. The grass is generally sedge grass which makes very good winter pasturage.

WATER.

There is plenty of water for stock in the creeks and rivers in ordinary years. The past years of drouth caused the citizens to construct many open tanks for stock water. Where the sites of these tanks are well selected they hold the water until dried up by the sun. Shallow wells can be obtained almost anywhere in the country, and the water is excellent for all domestic purposes.

W. F. CUMMINS,
Geologist for Northern Texas.

REPORT OF GEOLOGIST FOR EASTERN TEXAS.

RUSK, CHEROKEE COUNTY, TEXAS, December 8, 1888.

E. T. Dumble, Esq., State Geologist, Austin, Texas:

DEAR SIR—In accordance with your instructions to report on the iron ores and lignites of Eastern Texas, I proceeded on November 14, 1888, to Jefferson, Marion County, and after examining the deposits in that section, visited Van Zandt, Smith, and Cherokee counties.

The shortness of the time at the disposal of the writer to make this report has caused it to be more of a general than of a detailed character. It is purposed to embody a more comprehensive investigation in a later report.

THE IRON ORES OF EASTERN TEXAS.

The determination of the exact geological position of the iron-bearing beds of Eastern Texas, and especially of those north of the Sabine River, is a matter of some difficulty, as many of the associated strata are not fossiliferous. Enough data have not yet been collected to make any definite statements as to their exact geological horizon except in a few isolated cases. It is probable, however, that they occur in several different horizons between the lignitic clays of the Eocene and the Quaternary deposits which cap this horizon in the iron-bearing regions that have been visited. No analysis of ores collected by the writer have yet been made, but the best grades of Eastern Texas ores usually analyze from 40 to 50 per cent of metallic iron. The phosphorus and sulphur compose from $\frac{1}{10}$ to $\frac{1}{2}$ per cent of the ore. No other injurious ingredients are found in it. There is usually from 12 to 15 per cent of water, and from 8 to over 20 per cent of silica, alumina, etc. The iron ore in those counties visited, namely, parts of Cass, Marion, Smith, Cherokee, and Van Zandt, is very widely distributed but of very variable character and composition and occurs in varying quantities and associations.

The country in which the ore is found in these counties is elevated from 200 to over 700 feet above sea level. The prevailing formations are sands, clays, sandstones, iron ores, and lignite beds—all either lying horizontally or dipping gently to the east or southeast. The country is hilly, rising in broad flat-topped ridges or plateaus 200 and 300 feet above the surrounding lowlands and cut by numerous creeks and rivers. Springs are numerous, the interstratification of permeable and impermeable beds such as are found here being favorable to their occurrence. Some of them are ferruginous while others are pure. Numerous small streams arise from these springs, sometimes, however, running dry in summer, showing that the springs have a local origin and are not connected with any extended drainage system. Springs which are so connected, coming from a considerable depth and drawing their supply from a distant source, are not so dependent on the local and temporary fluctuations of the weather, and frequently do not show the effects of the drougth until months after it has occurred, and often run dry, consequent to the drouth, long after the rainy season has set in.

The country is heavily wooded with short leaf pine, oak of several kinds, hickory, ash, walnut, gum, grapevine, and other woods in smaller quantities.

The soils vary considerably from a buff-colored sand to the rich red and mulatto soils of Smith and other counties.

The iron ores are of several different varieties and have originated in several different ways. They may be classed for convenience as follows:

1. *Lake or Bog Ores.*—This variety is the result of the deposition of a hydrous peroxide of iron at the bottom of bays, lakes. or bogs. It has originated from the decomposition of iron pyrites or other ferruginous minerals, such as glauconite, hornblende, mica, augite, and other iron-bearing silicates, forming the mass of, or a part of, many metamorphic and eruptive rocks. These minerals on exposure are decomposed; the silica is set free and the iron carried off in a soluble form to be again precipitated in the form of an insoluble hydrated peroxide at the bottom of lakes, bays, or bogs. When pure, this ore, which is known as limonite, contains 14.4 per cent of water and 59.92 per cent of metallic iron. It is rarely, however, found in a pure state. The waters which carried it to its place of deposition were laden with other sediments, which were deposited with it. In physical character it occurs in many forms—laminated, massive, porous, stalactitic, and botryoidal, black, brown, or yellow in color, glossy, resinous, and dull in lustre.

This is the most important variety of iron ore in the region under consideration.

2. *Impregnations.*—This is generally an impure variety in the East Texas region. It is generally found in the form of a siliceous sandstone impregnated with ferruginous matter, carried to it in a manner similar to that described under lake ores. The ferruginous solution has percolated into the sandstone, been converted to the insoluble peroxide, and depos-

ited between the grains of sand. In this way often a bed of loose sand has been converted into a hard, brown ferruginous sandstone, containing necessarily a very variable amount of iron.

3. *Conglomerate Ore.*—This class is generally the result of the destruction of lake ores. It consists of worn pebbles of limonite from a fraction of an inch to three inches in diamter, cemented together by a brown ferruginous sandstone. Sometimes the conglomerate is made up of geodes of ore from one to twelve inches in diameter and cemented in a similar manner. Such an ore is not of very common occurrence, though the first variety of conglomerate is found in large quantities in the region under consideration.

4. *Clay Ironstone.*—This is an impure carbonate of iron, generally associated with considerable quantities of clay; gray in color, heavy, and found in nodules, round, flat, or in lenticular masses. It is generally brown on the outside from oxidation. The crystalized variety of this ore is known as chalybite, spathose iron, or siderite, but only the clay ironstone is found in the districts visited, and that in small quantities. The crystalized variety analyzes 48.3 per cent of metallic iron when perfectly pure.

Ores of one or more of the above varieties were worked during and after the civil war at various small furnaces throughout Eastern Texas. Among others were the Loo Ellen furnace in Marion County, the Nash and Sulphur Forks furnaces, in Cass County, and Young's furnace and others, in Cherokee County. The only furnace in blast now is a 25-ton one at the State Penitentiary, Rusk. A company has lately bought options on large tracts of iron land in Cherokee and are about to erect furnaces two miles south of Rusk. They have laid out a town known as New Birmingham. A Chicago syndicate has also lately obtained options on several thousand acres of ore-bearing lands in Marion and Cass counties with the intention of locating furnaces at or near Jefferson.

MARION AND CASS COUNTIES.

The iron ore in these counties occurs from a fraction of an inch to almost 10 feet in thickness. It is generally found lying horizontally on or near the tops of the hills and usually covered with a white or buff sand from a few inches to over 20 feet in thickness. Sometimes also, though not so often as in Cherokee County, the ore is capped with a stratum of hard siliceous ferruginous sandstone from an inch to over a foot in thickness. The line of separation of the sandstone and ore bed is sharp and well defined. Sometimes this sandstone occurs interbedded with the iron and at other times alone, without any ore bed. In one locality near the town of Jefferson, a bed of it was seen 12 feet thick, overlaid by sands and underlaid by mottled, white, brown, and red clays. The sandstone varies in texture from a close-grained rock with very fine sand to a coarse variety with grains the size of a mustard seed and larger. The cementing material is a brown ferruginous matrix. In color the rock varies from a dark brown to a bright red (on a fresh fracture).

Though the iron ore is usually found near the tops of the hills, one or more beds are sometimes found lower down in the hills, lying horizontally like the upper bed and separated from it and each other by sands and clays. The lower beds, however, are often thin and poor, often simply hard-pan.

This kind of formation gives a very characteristic appearance to the topography of the iron-bearing country. The horizontal strata have been cut through by numerous rivers and creeks, leaving flat-topped hills, ridges, and plateaus, with steep banks, and often forming buttes along the river courses resembling, on a small scale, those of the western cañons. The iron ore bed, capping the hills and forming a resisting barrier to the action of weathering, increases this effect to the extent that from a distant elevation it is often possible to tell which of the surrounding hills contain ore beds. This is especially true when the heavy covering of timber has been stripped from the hills, exposing their clear and characteristic outlines to view. The beds of the creeks are generally sandy from the detritus washed from the hill tops. Frequently, the creek beds contain large quantities of pebbles of ore broken from the outcrops of the ore beds above—rolled, rounded, and finally deposited at the foot of the hill. These have collected in such quantities in some places as to form a kind of soft conglomerate.

Occasionally benches have been formed on the slopes of the hills, caused by the alternation of soft and hard strata, the softer beds having been eroded, leaving the more resisting iron ore, sandstone, or hard pan. Sometimes also these benches have been caused by landslides, which have carried a portion of the top ore bed down to a lower level, often giving the appearance of a second ore bed, when it is really only the edge of the upper one. Probably some of these benches have also been formed by erosion in successive periods of elevation. These three causes render the nature of the benches often very uncertain, especially as they are generally covered by detritus from above, which obscures their true character. They are much more marked in Cherokee County than in Marion and Cass, there being in that county sometimes four or five distinct benches in distance of 100 feet from the hill tops.

There are also in this county more beds of variable hardness, which are conducive to such a formation, than in the counties north of the Saline.

The iron ore is generally much broken at the surface, and of very variable thickness. The ore is generally smooth on top, though often rounded and bulging below.

Although the ore is very generally distributed in Marion and Cass counties, it is in comparatively few places that it is rich enough or in sufficient quantities to work.

The following section is seen at Johnson's Hill, eighteen miles north of Jefferson:

(1)	Ore bed, laminated and in geodes, brown and black, bed much broken, probably	4–10 feet
(2)	Ferruginous and mottled clays	3 feet
(3)	Ore, similar to the laminated part of (1)	3–8 inches
(4)	Interbedded ferruginous sands and clays	20 feet
(5)	Mottled red and white sandy clays	10 feet
(6)	Red ferruginous sandy clays	65 feet

Stratum (6) runs to the bed of the creek at the foot of the hill, and probably extends below it.

Johnson's Hill is from two to three miles long and about a mile wide. The summit is capped with ore, generally in broken fragments. About a mile and a half to the southwest, on the Lasater property, was seen a much broken outcrop of yellow and brown limonite of good quality, overlaid by about twenty feet of light buff sands.

Again, at Barnes' Hill in Cass County, and about three miles northwest of Avinger, ore is seen in very large quantities, covering the hill top in large broken masses, somewhat similar to that at Johnson's Hill, three miles to the south. A few miles beyond this to the north is the old Nash furnace. Between Barnes' and Johnson's hills the country is rolling, and considerable ore was seen in places, sometimes thinning out and at others several feet in thickness. To the south of Johnson's Hill at Lasater Station on the Missouri, Kansas and Texas Railroad, the following section was obtained on Leverett's Hill:

(1)	Geodes of limonite, brown or yellow on outside, black and glossy on inside, kidney-shaped and rounded, one to twenty-four inches in diameter, mixed in brown sandy clay	2 feet
(2)	Iron ore bed, brown and yellow, black, laminated	2 "
(3)	Ferruginous sand to bottom of hill	10 "

Large quantities of this geode ore are said to have been used at the Loo Ellen Furnace, nine miles south of here, and a pile of several hundred tons of a similar ore is still to be seen there. The geodes are generally hollow, though sometimes they contain a coating of red ferruginous ochre on the inside, which is used by some for polishing metals.

Berry's Hill is seven miles north of Jefferson. It is a broad plateau comprising some 4000 acres, a large part of which is underlaid by iron ore. The following section shows the general mode of occurrence of the ore:

(1)	Red sandy clay with seams of ferruginous hard pan and rounded ore pebbles one-fourth to two inches in diameter	2 feet
(2)	Mottled sandy clay with same pebbles as (1)	5 "
(3)	Interbedded thin seams of limonite and ferruginous sands and hard pan	15 "
(4)	Mottled red and white clayey sands	10 "

Bed No. 4 runs to the foot of the hill and becomes covered by drift sands in the bed of a creek so that only ten feet of it can be seen.

The iron ore in the above section is a brittle laminated brown and yellow limonite. On a hill to the north of this exposure was seen a bed of conglomerate ore from one to two feet thick and at about the same level as the last mentioned bed. Some of the pebbles in the conglomerate bed appear to be fragments of broken up limonite geodes.

A quarter of a mile to the northeast of the last exposure was seen a series of alternating beds of conglomerate ore, laminated ore, and a variety composed of geodes from one to eight inches in diameter, cemented together by a sandy ferruginous matrix. Each of these beds are only a few inches thick, and are separated by sand and mottled clays, the whole series being about fifteen feet thick. The geodes are brown on the outside and black and glossy inside. They are generally hollow, though sometimes they contain masses of the same mottled clay as that separating the different beds of ore. The clays and sands separating the beds often contain loose geodes.

About a mile northwest of this locality and in the same plateau, the following section was seen in a pit:

(1) Sandy clay soil—dark brown—with ore pebbles and geodes composing two-thirds of the stratum.. ..... 12–15 inches
(2) Brown laminated ore with some concretions..... 6 "
(3) Ferruginous sands with concretions and hard pan.... ..... 18 "
(4) Ore in thin seams..... 4 "
(5) Mottled clays with thin iron seams and geodes..... 4 feet

These strata dip at 15 degrees to 25 degrees northeast, probably due to a local disturbance.

Going east and north from here similar ores are seen near Linden, Atlanta, Springdale, and other places. Near Springdale is a high hill, rising 512 feet above the sea level. The top of the hill is covered by a stratum of compact and laminated iron ore and ferruginous sandstone—about 2 feet in the thickest part seen. The ore appears to be sometimes interstratified with the sandstone and at others to be segregated in it. On this property was located the old Sulphur Forks Furnace, which was worked during the civil war. Similar deposits are to be found in many other places in Marion and Cass counties. The ore is generally associated with the mottled clays, the interstratified clays and sands, and the thick bed of red sandy clay shown in the Johnson Hill section. This clay is sometimes used to make brick.

Occasionally—as between Kilgore and Atlanta—the ore is underlaid by a pure white sand, associated with the other beds mentioned above.

Underlying the sands and clays of the iron-bearing formation is a bluish-gray clay, sometimes sandy. In this clay ironstones have been found in digging wells. But they were always, in the localities visited, in small quantities. They are of a light gray inside, and brown from oxidation on the outside.

Going west along the line of the Texas and Pacific Railroad, iron ore is found in Upshur, Camp, Gregg, and other counties. In Van Zandt the ore thins out, and entirely disappears when the Cretaceous formation is reached in the western part of the county.

The strata associated with the ores above described are barren of fossils, so that their exact geological horizon is as yet somewhat obscure. They overlie the lignitic horizon of the Eocene.

SMITH AND CHEROKEE COUNTIES.

To the south of the Sabine River in Smith and Cherokee counties the iron ore occurs in associations different to that to the north of the river. Large quantities of greensand, fossiliferous and non-fossiliferous, altered and unaltered, are found with it. The ore of this district is sometimes black, but generally of a brown or buff color, often of a greyish buff inside. It is glossy, resinous or dull in lustre, laminated and compact, the laminæ often being coated with a black glossy layer from one-twentieth to one-eighth inch thick. It is often crumbly when broken. Generally capped with sandstone one to twelve inches thick. The bench formation is very marked in the country about Tyler, Mt. Selman, Jacksonville, and other places. Frequently it is caused by banks of indurated green sand.

The iron-bearing localities are characterized by the same ore-capped hills as in Marion and Cass counties, and such elevations as Mt. Selman owe their height and often their existence to their protecting cap of iron ore. Mt. Selman is the name given to a part of the divide between the Neches River and the headwaters of the Angelina River known as Mud Creek. The summit of this divide is a long strip of elevated plateau land commencing near Tyler and running S. S. E. in an almost unbroken line to near Jacksonville, where it is cut by a deep gorge. From here it continues on in a more or less brokenr idge. It is from forty yards to several miles wide, and rises from 531 feet at Tyler to over 700 to the south of Mt. Selman. Thence it falls again to 525 at Jacksonville. From its summit the ridge slopes rapidly for the first 150 to 200 feet, and then more gradually, reaching the Neches on the west in from eight to twelve miles and Mud Creek on the east in from four to seven miles. The land slopes off in a series of undulating ridges and hills covered with a thick growth of pine, oak, hickory, etc. The ridge is narrowest from Bullock to Jacksonville, a distance of about fourteen miles. Between these points ore of good quality was seen in many places, and caps the ridge for a larger part of the distance, in a bed varying in thickness from a few inches to over six feet.

The following section, from the east slope of the ridge, about three miles south of Mt. Selman, shows the mode of occurrence of the ore:

(1) Buff-colored sands . ..... 10 feet
(2) Brown laminated ore..... 3–6 feet
(3) Fossiliferous yellow rock, soft, easily cut with a saw (altered greensand)..... 12 feet
(4) Greensand, soft, fossiliferous..... 2 feet

Below this the slope of the hill is covered by detritus, so that the underlying formations are obscured as well as the base of (4), but exposures seen near by, show the underlying

beds to be a series of interbedded ferruginous sands and gray clays. The ore is of good quality and, sometimes, in large quantities.

Two miles south of Mt. Selman, and on the line of the Kansas and Gulf Short Line Railroad, is seen a cut showing seven feet of a black, compact, and laminated ore.

Just beyond this the following section was observed:

(1)	Dark, scaly ore, mixed with rusty greensand	2 feet
(2)	Indurated, hard, rusty greensand, with thin seams of ore running in every direction through it	3½ feet
(3)	Soft greensand, fossiliferous, cut by ore as in (2)	4 feet
(4)	Hard pan with greensand grains	⅔ feet
(5)	Greensand, same as (3)	5 feet
(6)	Black laminated ore, scaly	1–1½ feet
(7)	Fossiliferous greensand	1–1½ feet
(8)	Ore, same as (6)	1–2 feet

The greensand in beds (2), (3), and (5), is cut by numerous seams of ore from one-eighth to two inches thick, running through it at all angles and both in straight and curved lines.

Half a mile south of this exposure the following section was seen in a cut:

(1)	Soil, red sandy clay	1–2 feet
(2)	Poor ore, laminated	1 foot
(3)	Soft, partly altered greensand	3 feet
(4)	Poor ore, laminated	1 foot
(5)	Soft, partly altered greensand	1 foot
(6)	Poor ore and rusty greensand interbedded in seams from 1 to 3 inches thick	6 feet
(7)	Fossiliferous greensand	6 feet

Near by in another cut:

(1)	Interstratified laminated ore and altered greensand, the iron ore beds composing about one-half to two-thirds the mass, ore poor	14 feet
(2)	Bright green indurated greensand, fossiliferous	2–3 feet
(3)	Blackish, clayey greensand, fossileriferous, and still in bottom of cut	2 feet

The greensands in the above sections generally contain fossils unless the alteration has destroyed them. Many of them are much obscured, but Claiborne forms were observed in some. especially in the soft yellow rock which underlies many of the iron ore beds. From the ridge at Mt. Selman can be seen the hills on the divide between Prairie Creek and West Mud Creek, fifteen or twenty miles to the northeast. Good ore was found here in several places from one to three feet thick. It is of the same general character as that near Mt. Selman.

On a small creek, six and one-half miles southeast of Tyler, the following exposure was seen:

(1)	Iron ore, laminated, scaly	6	inches
(2)	Greensand, indurated in places and interbedded with thin seams of iron,	10	feet
(3)	Interbedded thin seams of blue clay and ferruginous sand with seams of ore one-eighth to one-fourth of an inch thick	3	feet
(4)	Laminated ore	4	inches
(5)	Interbedded thin seams of blue clay and ferruginous sand with seams of ore one-eighth to one-fourth of an inch thick	2	feet
(6)	Laminated and scaly ore	3–8	inches
(7)	Interbedded thin seams of blue clay and ferruginous sand with seams of ore one-eighth to one fourth of an inch thick	6	feet
(8)	Fossiliferous greensand	3	feet
(9)	Laminated ore	2–6	inches
(10)	Fossiliferous greensand	1	foot
(11)	Laminated ore	2–6	inches
(12)	Greensand, indurated in places and interbedded with thin seams of iron,	2	feet
(13)	Interbedded thin seams of blue clay and ferruginous sand with seams of ore one-eighth to one-fourth of an inch thick	2½	feet
(14)	Massive and laminated ore	3–12	inches
(15)	Interbedded thin seams of blue clay and ferruginous sand with seams of ore one-eighth to one-fourth of an inch thick	3	feet

The ore in the above section is a yellow or brown limonite, massive or laminated, brittle, and often of good quality. Sometimes the greensand has a rusty appearance, and at others is in the form of a hard, waxy marl.

The interstratified sands and clays of (3) consist of thin beds one-fourth to two inches

in thickness. The clay is a light gray, the sand of ferruginous brown, sometimes a hard pan. The strata are all horizontal.

Going south towards Jacksonville along the line of the narrow gauge road, the ore begins to thin out about three miles north of the town, to begin again some six miles south of it, and run thence to Rusk. Four miles to the southwest of Jacksonville the ore is met again in a series of hills, running thence to the Neches River. The ore is similar in quality to that near Mt. Selman, and needs no special description. Below is a section on the side of one of the hills:

(1) Gray and buff sands	10	feet
(2) Ferruginous sandstone, siliceous	1–8	inches
(3) Brown, laminated, and compact ore	1–2	feet
(4) Yellow, soft, fossiliferous, altered greensand	30	feet

Below (4) the formation is obscured by detritus.

About two miles west of Jacksonville a small deposit of conglomerate ore was seen. But this variety does not occur so abundantly in this county, so far as seen, as in Marion and Cass.

Limestone suitable for the manufacture of pig iron is found in several places throughout the iron-bearing region, sometimes in the cretaceous outcrops, such as those of Anderson, Cherokee, and other counties, and at others in beds of the Mansfield formation. These deposits have not yet been visited by the writer. The limestone used at the Rusk furnace is brought from near Austin.

In conclusion it may be said that the iron ore in many places in the counties visited occurs in quantities fully sufficient to warrant the erection of furnaces and to give every promise of success. Coal is not found nearer than 125 to 200 miles, but timber is plentiful, and charcoal, for use in iron furnaces, can be made cheaply.

LIGNITES OF EASTERN TEXAS.

Lignites occur in very many places in eastern Texas, but only comparatively few of these have as yet been visited by the writer. They belong to the lowest division of the Eocene formation, known as the *Lignitic* (Hilgard). This formation is exposed in various places between the Cretaceous formation as its western boundary and the Clairborne and Mansfield formations on the south and east.

The lignite occurs in from one to four different beds—varying from a few inches to an average of 2 to 8 feet thick, though beds of over 20 feet in thickness have been reported. The lignite is variable in character; sometimes soft and crumbly, of a dark brown, or black color at others more woody and coherent; and again sometimes of a bright glossy jet-like consistency with a cubical or conchoidal fracture. It is often compact when first dug and crumbles on exposure to air. It has not yet been used to any extent for practical purposes. The main difficulty seems to be in its soft and crumbly character, and its value is also greatly impaired by the presence in it of from 15% to over 20% of moisture. It varies considerably in chemical composition, containing, besides moisture, from 16% to 50% of volatile matter, 20% to almost 60% of fixed carbon, and 4% to 14% of ash. The samples that have been tested are reported not to coke, and to burn with a white or a red ash—according to the amount of iron present. The beds frequently contain large quantities of iron pyrites and are at other times entirely free from it.

The lignite might possibly be prepared in bricks, cemented by some such material as coal tar or asphaltum, and would then be more serviceable. It could also be used for clarifying sugar—for which purpose it is now being used in Germany, where large deposits of lignite occur. It might also be made of value as a source of gas.

The lignite beds were seen in large number of outcrops in Van Zandt County, where they appear in many places along the Sabine and the creeks draining into it. They are also found in digging wells almost all over the county, until the Cretaceous formation is reached near its western border.

The following section is on Little Saline Creek, 7 miles north of Canton:

Gray plastic clay	6	feet
Lignite	1–1½	feet
Chocolate colored and black lignitic clays	5–6	feet
Lignite to bed of creek and still in bottom	2	feet

The lignite is sometimes in lenticular deposits, and is occasionally interbedded with dark brown lignitic clays, which turn a light buff color when burned. The dip in the above section varies from horizontal to a gentle incline to the southeast. The lignite clays come to the surface in many places in this locality, though often covered by a variable thickness of sand.

Below is a section in the well of Joel King, 10 miles northeast of Canton:

Surface sand	1 foot
Gray plastic clay	8 feet
Red sand	5 feet
Dark blue marl	10 feet
Lignitic clay—dark, gray, shaly	20 feet
Lignite	2 feet
Lignitic clay—chocolate colored	5 feet

The lignitic clays are often of a gray slate color, partly indurated, and of a shaly or slaty strncture.

The water from wells in the lignitic clays and lignites is sometimes strongly impregnated with iron, due to the decomposition of iron pyrites. In some cases, however, the water is pure.

Going west along the line of the Texas and Pacific Railroad, the lignite beds are found to end east of Wills' Point the most westerly deposit heard of along that line being found in a well on the property of James Moore, about 7 miles east of the town. To the west of this exposure are found outcrops of a white, non-fossiliferous, clayey sand. It is soft when wet, but hardens on exposure to the air. Beyond this the land is mostly low, flat, and sandy, until, about 4 miles east of Wills' Point, the timber ends abruptly, the soil becomes more clayey and darker, and the black prairie land begins.

Tertiary fossils were found in a hard white limestone rock in Rocky Cedar Creek, 4 miles west of Wills' Point, and just across the western boundary of Van Zandt County. In some places this rock is composed almost entirely of shell casts.

Between Cedar Creek and the timber on the east, the country is rolling, and the soil a black clay, underlaid by interstratified blue-gray clays and yellow sandy marls. This clay and marl formation sometimes contains nodules of white limestone from ¼ to 2 inches in diameter. Crystallized gypsum is also found in it in some places. Fragments of a gray or buff colored limestone, from the size of an apple to masses of several hundred weight, are scattered over the prairie between Cedar Creek and the timber; also hard, silicious, worn boulders of a white, brown or red color are found, varying from 2 to 10 inches in diameter. Occasionally concretionery masses of limestone, weighing a ton or more, are found.

At Grand Saline, 15 miles east of Wills' Point, salt has been found in boring, at a depth of 200 feet—the overlying strata being clays and sands, sometimes containing beds of iron ore and sandstone. No samples of the iron ore reported to have been found were seen. Petroleum in small quantities is also said to have been found at 100 to 150 feet, in a slaty, blue clay. They have bored into the salt for a depth of 125 feet, and have not yet reached the bottom of the bed. The well is now 325 feet deep.

The above information as regards the strata passed through in boring, was given to the writer by the manager of the works. The saline is an open flat, covered with scattered tufts of grass. It is about one mile long from east to west and a half mile wide. Saline Creek runs past its southeast corner, and thence into the Sabine about three miles distant. The saline is surrounded by low sandy hills, and is connected with the Sabine River by a series of flat, swampy, and heavily wooded thickets. In rainy seasons the waters of the Sabine River rise and flood the saline and the intervening country. Shallow wells were worked for salt here over twenty-five years ago.

Following the lignitic formation towards the east, lignite beds are found in all the country lying between Van Zandt County, along the line of the Texas and Pacific, and the eastern boundary of the State, though in some places it is at considerable depths. At Alamo, Cass County, a shaft is now being sunk to work the lignite deposits of that region. In boring, the following section was obtained:

(1)	Sands and clays	26 feet
(2)	Clay—grey, indurated, slaty	23 feet
(3)	Lignite	20 inches
(4)	Sand	2 feet
(5)	Clay, same as (2)	9 feet
(6)	Lignite	4 1/6 feet
(7)	Clays and sands	14–26 feet
(8)	Lignite	½–6 feet

The thickness given for beds (7) and (8) are the results of borings in different places. The country in which this work is being done is flat and swampy.

Many other deposits of lignite occur throughout many parts of the eastern counties of Texas, but, on account of lack of time, only a few of them have as yet been visited by the writer. Large deposits are found in Leon, Limestone, Robertson, Smith, Wood, Henderson, Rains, and other counties.

R. A. F. PENROSE,
Geologist to Eastern Texas.

REPORTS OF GEOLOGISTS FOR SOUTHERN TEXAS.

SAN ANTONIO, TEXAS, December 9, 1888.

E. T. Dumble, Esq., State Geologist, Austin, Texas:

SIR—I have the honor to transmit my enclosed report as per your request dated the 8th ult.

It was impossible in the short time allowed to make more extensive investigations of the counties named, and I have also been greatly hindered in my work by the almost continuous rainy weather.

I aimed to adhere strictly to the instructions as contained in your communication, with special reference to the existence of useful rocks and minerals, and therefore the following examinations and investigations are such as were dictated by practical experience and previous knowledge of the section.

TOPOGRAPHY.

The ten counties, to-wit, Gillespie, Kerr, Kendall, Bexar, Blanco, Comal, Wilson, Guadalupe, Gonzales, and Caldwell, are situated between the Colorado and Nueces rivers, and contain a surface measurement of 8535 square miles. The northern part of this territory is mountainous; the southern part is hilly, undulating, and flat. The mountainous country begins about fourteen miles north of San Antonio, extends over the northern part of Bexar County, the whole of Kendall, Kerr, Gillespie, Blanco, and a part of Comal. The southern boundaries of these mountains are Helotes, Leon Springs, and continue in the same direction along the Salado and Cibolo. These mountains rise from one to two thousand feet above the sea level. Between the Guadalupe and Pedernales and also between the Palo Alto and Crab Apple creeks are extensive plateaus. Extensive valley formations are to be found along the course of the Guadalupe in Kerr and Kendall counties, and along the course of the Cibolo in Kendall County, and in the course of the Leona and Salado in Bexar County, as well as the extensive valley of the Pendernales in Gillespie County. The many creeks form innumerable smaller valleys and hollows. The whole surface configuration of the county creates the impression that its existence was formed by continental rising in Cenozoic time—the horizontal strata of these mountains proving beyond a doubt that a continental rising must have taken place.

GEOLOGY.

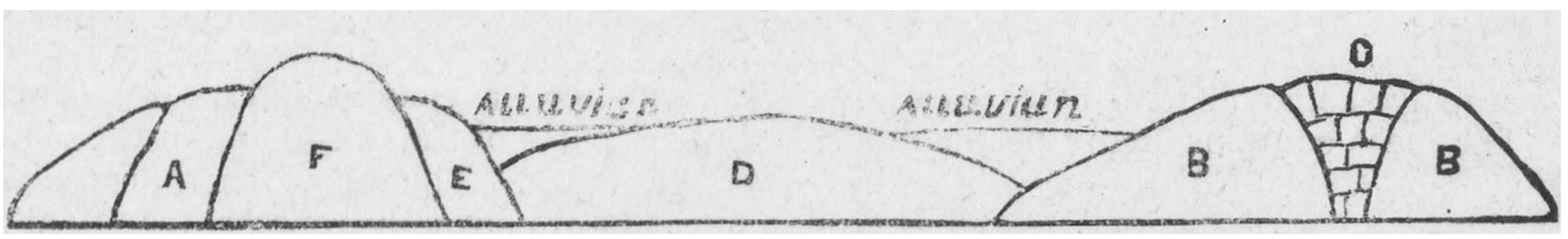
Within this territory, as far as my investigations go, there are found the following formations: the Primary (of the sedimentary), the Jurassic, Cretaceous, and Tertiary formations, and the Quaternary or Diluvium and Alluvium.

Paleozoic.—The Primary formation occurs in the northeast part of Gillespie County, beginning at a point between Crab Apple and Sandy creeks. The rocks are micashist, changing into grey granite, slate, and as subordinate rocks, chloritschist, serpentine, granular limestone, quartzite, garnet rocks, and magnetic iron, which latter forms a mountain one mile long by one-half mile wide.

The serpentine has a dark green color, and is not of eruptive origin; the garnet rock contains beautiful dark red almandin crystals of considerable hardness as well as fine crystals of vesuvianite. Among the quartzes some which are pure white occur in large quantities in the magnetic iron ore, while rose quartz and blue tinted milky quartz are found in the granite. An interesting feature is the granular limestone or marble which appears in a large fracture in the granite. The fracture is from twenty-five to thirty feet wide on the surface, and can be traced for a distance of some two hundred feet in length. The hard and coarse granular limestone is of a white color, and in the proximity of granite is of a bluish coloration from the admixture of particles of graphite.

The following section of these rocks give a fuller explanation of the method of their occurrence:

FIG. 10.



SECTION SOUTH OF ENCHANTED ROCKS.

(A) Micashist with change into granite. (B) Granite. (C) Granular limestone. (D) Serpentine. (E) Garnet-rock. (F) Magnetic iron. In the neighborhood of Enchanted Rocks graphite makes an appearance.

The other Paleozoic formations are entirely wanting or do not appear on the surface in the territory here described. Of the Mesozoic time we have the Jurassic and the Cretaceous formations represented

Jurassic.—Rocks resembling the Jurassic occur in Bexar County about three miles east of Helotes. The rooks are white and light yellow, compact and hard limestone, sandy clayish granular hard limestones and lamellar siliceous limestones, with few petrifactions. Between the Leon and Salado twenty-three miles from San Antonio, this Jurassic appears in several places in greyish and yellow-tinted lamellar limestone and dolomite.

Again, four miles east of Kerrville, Kerr County, in the northeast of Kendall County, and in the southeast of Gillespie County, where there are large layers of white, yellowish, red, and blue veined limestones, which are of a high grade of solidity and density, and are therefore subject to fine polish in the shape of valuable marbles. The same formation occurs twenty-three miles north of Fredericksburg, at Cherry Springs, consisting of alternate layers of the same hard granular limestone, similar to those near Helotes, and also a compact grey limestone, which is even now worked as marble, although it does not possess the even structure of the former, and hence is less beautiful than it. Here is also a large layer of quartz sandstone of a considerable hardness.

Cretaceous.—The Cretaceous formation is found in these mountains about four miles in a northwesterly direction from Leon Spring. The strata belong to the Upper Cretaceous formation, and lay directly on the top of the Mans formation, consisting of marls and yellowish chalk, and contain many petrifactions of echinoids and cyclolites. On the Olmas Creek in the vicinity of the Salado, the Cretaceous formation appears with light yellow marl slate; over this marl slate lies a deposit from three to six feet thick of flint gravel covered by sandy earth. From the Olmas range the Cretaceous formation occurs in the direction of San Antonio, where it appears as a soft limestone with amonites and nautilus petrifactions, and marl slates. On the Leon, fourteen miles west of San Antonio, there are greensand deposits, which belong in the same formation.

Tertiary.—Of the Cenozoic time the Tertiary formation is most prominently represented in the mountainous part where the Diluvial and Alluvial deposits are only to be found in the valleys and on mountain declivities; while the Alluvium and Diluvium occur in the southern hilly, undulating, and flat part of this territory, which stretches out from the foot of the mountain ranges in a dominant quantity, and thus covering all deeper lying Tertiary.

The Tertiary formation consists here mostly of large layers of coarse grained limestone, sandstone, clay, sand, and gravel. The limestone forms heavy and extensive layers on the Leon, the Balcones near Kerrville, and other places. The coarse grained sandy limestone is soft while hidden, but becomes harder when exposed to the air. At many places this limestone is full of petrifactions, as for instance about three miles west of Kerrville, where it forms a conglomerated mass of shells which possibly belong to the Miocene.

Tertiary sandstones appear in many layers near Cherry Springs, Gillespie County, in connection with some rich red iron ore; the same also appear in various places along the Helotes, the Medina, and many other places, with clay deposits. These may belong to the Pliocene. On the right bank of the Medina there is a large layer of hard, bluish colored sandstone, which is similar in appearance to Eocene sandstone, but since I could not find any petrifactions, it must remain uncertain whether it belongs to Eocene or to the Cretaceous formation.

Grey and yellow clay of the Tertiary formation of a plastic nature are to be found in large quantities in the undulating lands and plains of this territory, at all depths, from twenty to five hundred feet, alternating with deposits of sand and soft yellow sandstones, which I have observed many times in the boring and digging of wells. Deposits of white and yellow fine grained crystal sand appear in the surface at Cherry Springs in Gillespie County, and also in a cave seven miles north of Fredericksburg, in which it occurs in great quantities, as well as in the vicinity of Calaveras, Wilson County. Pyrites are found in the large clay deposits near Blanco, Blanco County, and four miles east of San Antonio. Some twelve miles south of Fredericksburg, while a well was being dug, metallic iron was found in the same clay. Brown iron ore and bean ore deposits are scattered in the Tertiary formation, and appear on the surface in many places in the vicinity of Helotes, Bexar County, and Cherry Springs, Gillespie County. Ochre is found fourteen miles west of San Antonio; bean ore (Bohnerz) near Helotes, on the Salado, Cibolo, and other places, with some fine petrifactions.

The Quaternary Formation.—Diluvium is dominant in all this territory. In the mountains and in the hilly country there are grand loess deposits of coarse gravel and sand that fill the valleys. These cover the hill and mountain sides, which, with the bottoms, are covered with the same and with black earth, and thus produce the richest and most productive soil. The loess contains many petrifactions, including parts of the mastodon, in the vicinity of Calaveras, Wilson County, as well as in Gonzales County. The black earth contains in many places flint rocks. Yellow and gray clay deposits are strongly represented in all the lower parts of the territory, as in Bexar and Wilson counties. We also find the Alluvium

in all the adjuncts of rivers and creeks, in the form of coarse gravel with sand deposits intermixed, which are continually forming.

Eruptive Rocks.—I have up to date found the following plutonic rocks in this territory: The "Barrenberg," five miles northeast of Fredericksburg, which consists of large and coarse grained red granite, in which the red feldspar is predominant in particles from small to large dimensions; the "Enchanted Rocks," on the northeast edge of this territory, consisting of red granite, and in Cherry Springs a granite hill known to the inhabitants of the county by the name of Dead Volcano.

These notes are entered only as a guide to a closer examination and study for future Geologic Survey and to assist in a more thorough and detailed exploration of the formations and their respective contents.

ECONOMIC PRODUCTS, USEFUL ROCKS AND MINERALS.

Iron.—The most important of the economic minerals in summing up is the magnetic iron ore, three miles southeast of Enchanted Rock, in Gillespie County. This is the mountain of which mention has already been made, which consists of a compact magnetic iron ore, and contains 71 per cent of pure iron, in many places possessing polarity (natural magnet or lodestone). The ore is of the same quality and value as the magnetic iron ore of Danamora and Sweden. It there forms the foundation of an extensive iron industry, and the like of which will, it is hoped, be developed also in this country, increasing thereby the natural resources of the land and people. It now lies as a great treasure worthless.

At Cherry Springs, Gillespie County, there are valuable red iron ores (hematites), which contain 68 per cent of iron. The locations are in sandstone, and a large quantity of fragments of the same iron ore lies on the surface far from the stratum. In the vicinity of this place are also valuable brown iron ores (limonites), which are waiting to be made of value.

Here should also be mentioned the bean ore (Bohnerz), found at many places in large quantities, as on the Salado and Helotes, which, however, can hardly be used in iron production. Yellow and red mineral limonite (ochre) is found in many places. One deposit of sufficient dimensions to be of economic value is situated fourteen miles northwest of San Antonio.

Of other ores in this country not much can be said. In my travels in the northern counties, the people brought me many pieces of ores containing silver and lead for examination, which were said to have come from the respective counties named, but after a close examination these claims proved to be false. Copper ores are found, especially chalcopyrite, in a contact vein between granite and granular limestone near Crab Apple Creek. Pyrites can be found near New Braunfels, Comal County; near Blanco City, Blanco County; and four miles east from San Antonio, at which places it is situated at considerable depths in deposits of bluish clay, and can be made useful in the fabrication of sulphuric acid.

Building Stone.—Of greater interest, however, in regard to usefulness, are the masses of sedimentary rocks. Of the granites the only one so far used is the one quarried at Barrenberg, five miles from Fredericksburg. This is a fine building and ornamental stone, but contains too much feldspar, and is not of such superior quality as the granite from Crab Apple Creek, which is close-grained and subject to a fine polish, but which has not yet been brought into use. The red granite of Cherry Springs is of an equally superior quality.

The serpentine of Crab Apple Creek can be made useful as building and ornamental material.

Micaschist and chloritschist are fire-proof materials for smelting ovens, for which purpose it is hoped they will soon be in demand.

Pure quartz occurs in large masses in the Primary formation, and can be used for glass production. Pure white and yellow quartz sand can be had in large quantities at Cherry Springs, and seven miles west of Fredericksburg, near Calaveras, and is now being used by the people for many purposes.

Limestones as found in that territory are well adapted for building, ornamental, curbing, and other useful purposes.

The granular limestone found near Crabb Apple Creek, of which I have already spoken, is a very fine marble, similar to the Carara. It occurs in large quantities, but is so far unused. Common marble is found at Cherry Springs, which is now being brought into use. Another of better quality and therefore of greater value, white, gray, and of different colors, and susceptible of a fine polish, occurs west of Fredericksburg in large masses, but is so far unused.

Dolomite occurs at Leon Springs, and lithographic stone in the vicinity of Helotes, both in large layers, as yet unused.

Of all rocks, however, which are found in this country, the Miocene coarse grained limestone is the most desired material for building purposes. This is on account of its desirable qualities of low specific gravity, and that of hardening when brought into the air. Owing

to its structure it is easily worked, and while at the same time it is not as durable as the rocks mentioned previously, yet is being used in large quantities from the quarries near Kerrville and the Balcones near Boerne.

The more compact limestone (Jurassic?) furnishes a fine quality of lime, which is manufactured at many places in primitive kilns. San Antonio is supplied with lime from the Salado.

Among the sandstones should be mentioned one to which reference has already been made—the hard blue variety which is found on the Medina, but which is up to the present in little use. The hard quartz sandstone at Cherry Springs furnishes fine material for grindstones, mill-stones, and for building purposes.

Marl and loess can be used in many places for the manufacture of cement, and the cement made at San Antonio from native material has stood some very severe tests.

Plastic yellow clay exists in the counties of Bexar and Wilson in large quantities, and forms a first-class material for the manufacturing of brick and pottery ware, and is now being used on the Caliveras at Floresville.

Lignite.—Most positive proof exists of the presence of large deposits of lignite in the southwestern counties, but it has also been discovered at greater depth some twenty-nine miles west of San Antonio, where a fifty feet shaft has been sunk to a layer five feet in thickness, which is covered by blue clay.

Mineral Waters and Artesian Wells.—Springs of mineral water are found in Kerr County, two miles West of Kerrville, and sulphur water at Sutherland Springs, in Wilson County. There are rich sulphur springs near the Cibolo, which are used by many visitors for bathing purposes, though no accommodations of any kind exist, at which place it would be a blessing to suffering mankind if comfortable conveniences could be provided and an easy approach be had to these health restoring waters.

The territory contains but few artesian wells, and these were sunk for the specific purpose of obtaining water, and it is to be regretted that the borings were made by parties who had no scientific knowledge of rocks, much to general detriment of science. Among the most prominent of these wells I would mention the following: One of a depth of 225 feet in the western addition to the city of San Antonio, with a fine quality of drinking water, which forces its way to the surface. Another four miles east of San Antonio, near the Salado, which was sunk to a depth of 450 feet, and also brings a constant stream of water, containing hydro-sulphuric acid, to a considerable height. It is clear, and is being utilized for the ordinary wants of man and beast, but could be made more useful on account of its medical qualities.

Petroleum.—A more valuable well has been sunk about seven miles south of San Antonio, which, instead of water, at a depth of 350 feet uncovered a deposit of gray clay ranging down to a depth of 420 feet, which is thoroughly impregnated with tar. This tar is of a syrupy consistence and of a dark yellow color. The well thus far gives only a barrel of twenty gallons of the tar per day, but nevertheless has been brought into market as a lubricator for wagons, etc. It contains a large quantity of coal oil, but is not refined. There seems to be no doubt whatever that this is the distilled product of a deeper and large bed of brown coal.

From investigations, as near as I could make them, I found that the various deposits on the top of the clay containing this tar consisted alternately of sand, plastic clay, and gravel, of which the lower probably belong to the Pliocene period, while the upper are Diluvial deposits.

GUSTAV JERMY,
Geologist.

SAN ANTONIO, December 8, 1888.

E. T. Dumble, Esq., State Geologist:

DEAR SIR—In pursuance of your instructions of the 8th ultimo, directing me to examine and report (so far as practicable within the time allotted, viz., the 10th instant) on the minerals existing in the counties of Edwards, Bandera, Medina, Frio, Atascosa, La Salle, and McMullen, I beg to report that I have visited all of said counties except McMullen, and endeavored to ascertain, partly by personal inspection and partly by reliable information, the desired information. I could have done considerably more field work had I not encountered continuous rain for the first three weeks I was engaged in this work, which I need not say was a matter of much regret to me.

EDWARDS COUNTY.

Edwards County, the first named of the group and the most northerly, is bounded on the west by the Nueces River and on the east by the Frio River, both running in bold streams

in a south to southeast direction across the dip of the strata of that section. Intermediate the Hondo and Sabinal flow in the same direction, but are lesser streams.

Topography.—The topography of the county is extremely picturesque and well defined, the principal features of which are a succession of rounded and terraced hills, ranging generally north and south, with intervening valleys of no great width.

Formation.—The formation is strictly Cretaceous, and consists of massive limestone, with the exception of the lowest visible stratum, which is a pure white chalk, compact and homogeneous. As there has been some question raised in regard to the existence of chalk in North America, the matter is one of interest. Having had an opportunity in Europe to examine the Cretaceous formations there, the chalk is very familiar to me and is unmistakable. Owing to the comparatively easy erosion of the chalk the superincumbent strata of limestone have given way and large masses of that rock have been precipitated into the valley below, giving rise to perpendicular cliffs, especially on the river banks. These cliffs present very distinct sections for stratigraphical examination, and I was very desirous to avail myself of the opportunity, but the almost continuous rain while in that section prevented me from making the attempt.

The Soil.—The soil is a composite of carbonaceous matter and lime, and is very productive when properly cultivated. During the past season the crop of cereals has been one of the best known in that section. The grasses, principally of the mesquite variety, are also good and abundant. The timber growth is principally cedar, which is valuable where a market can be reached.

Kaolin.—As my first object was to examine the deposit of kaolin, or china clay, I made my way to Leakey, the county seat, for that purpose, ascertaining that the deposit was about eight miles from that town. In company with Mr. Barnet, the manager and part proprietor of the mine, I visited that section and found the works on an elevated plateau about 400 feet above the level of the valley in which Leakey is situated. A massive intrusive dyke of feldspathic porphyry in part traverses this plateau; and as the kaolin deposit lies contiguous to it, the kaolin is obviously derived from the decomposition of the feldspar porphyry. The dyke runs in a northeasterly direction and is traced for several miles, appearing and disappearing at intervals. Several shafts have been sunk on the deposit. The main shaft has gone through the kaolin thirty-three feet without any evidence of exhaustion. The dimensions of the deposit, so far as at present ascertained, are a length of 1200 feet by a width of 250 feet. Shafts have been sunk at intervals for the purpose of testing these dimensions. I found in the upper part of all the shafts that the kaolin was tinged more or less with metallic coloring, due to the presence (determined by analysis) of iron, manganese, and cobalt, traces of which are found in the dyke, together with a little asbestos. As the shafts go downward the kaolin becomes purer, and a fine white china clay is ultimately obtained, good specimens of which I carried away with me. A company has been formed to work the mine and a force of men are actively employed getting out the kaolin for shipment to New York. One car-load (40,000 pounds) has already been sent on, and the manager, Mr. Barnet, informs me they intend to work up to fifty tons per day as soon as their arrangements are perfected. The carriage to Sabinal depot, on the Southern Pacific Railroad, is forty miles by wagon, but it is an easy down grade and presents no difficulty in good weather. I was reliably informed that similar dykes have been observed in the northern part of the county, and some more indications of kaolin are observable in their neighborhood. Should such prove to be the case, a large and profitable industry will be the result. I also observed that the limestones in contact with the dyke had assumed a crystalline form, and if this exists to any extent, a good marble may be obtained therefrom.

Sulphur.—About eight miles southwest of Leakey, a deposit of sulphur has recently been discovered, which was described to me as pure and very considerable in quantity. The roads were so bad I could not reach it for examination, nor could I procure a sample of it.

Gypsum.—A bed of gypsum in massive form has been found ten miles south of Leakey, a sample of which I obtained.

Brown Hematite.—A bed of excellent brown hematite, fifteen miles north of Leakey, has been observed on public land. It is a close, compact ore, without admixture, and will probably yield 50 per cent of metallic iron.

Lignite.—A bed of lignite is also known to exist about three miles from the ore, with an outcrop of eighteen inches. That section of the county where these minerals occur is on the average about forty miles distant from the Southern Pacific Railroad, and if an effort was made toward manufacturing, a tap road could doubtless be secured.

BANDERA COUNTY.

Bandera County, which I next visited, lies immediately adjacent and east of Edwards County, presenting the same general topographical features and geological structure as the latter county. The Frio River is the dividing line between the counties, and the Medina, on

which the county town of Bandera is situated, flows down through the centre of the county, and is a fine bold stream. The Hondo, the Seco, and the Sabinal creeks run also through the section.

The minerals known at present to exist in Bandera County are as follows:

Lignite.—A bed of compact lignite fifteen miles southwest of Bandera City on Wynan's Creek. At the outcrop it is about fifteen inches, and is said to increase in thickness when dug down upon, but as no systematic work has been done, the actual thickness of the bed is not accurately known. The sample shown me was much better than the average, and would make a good domestic fuel, being clean and compact.

Another seam of lignite is found on the bank of the Hondo Creek twenty miles west of Bandera City; it is stated to be all the way from two to three feet where exposed. I did not see a specimen of this coal, nor could I get any further information regarding it, as it was impossible to reach the locality.

Brown Hematite.—On the headwaters of the Medina River, 35 miles northwest of Bandera City, a large deposit of massive brown hematite is exposed. The specimens shown me are very similar to those seen in Edwards County, and may be a continuation of the same stratum.

Gypsum.—There are two large beds of gypsum that crop on the Medina River 23 miles north of Bandera City. One of these beds assumes an alabaster form and has the characteristic color and lustre of that mineral.

Chalk.—A stratum of chalk lies exposed in the Medina Valley, 2 miles south of the county seat, and is of the same general appearance and quality as that I saw in Edwards County, 5 miles north and 15 miles southwest of Leakey.

Soapstone.—A soapstone stratum lies 16 miles southeast of Bandera City, and can be reached from Boerne on the Aransas Pass Railroad at a distance of 10 miles. In the event of iron manufacture in the county this mineral would be of value in fire hearths and furnaces, also for domestic purpose, for which it is now locally used.

Brick Clays.—In the southern part of the county good brick clays, yellow and red, abound. From my examination of them I feel satisfied of their superior quality for that purpose, although now undeveloped. The abundance of excellent and easily workable building limestone around Bandera City has rendered brickmaking in that locality unnecessary.

Building Stone.—In this connection I may state that the building stones of Edwards, Bandera, and Kerr are of two kinds—the one a granular and slightly silicious limestone of yellowish tinge, the other of a light cream color, fine grained, and susceptible of a fine cut surface for ornamental work such as cornices, fluted columns, etc. The City Hall of San Antonio, which is now building, will present a good example of the former, and the large and imposing Federal building now in course of erection shows the latter to advantage. Much of the information I obtained in this county was through the courtesy of Mr. Hudspeth.

Dyke.—There is an intrusive dyke of basalt about 2 miles north of Bandera City, which I had an opportunity of seeing. Mr. Hudspeth thinks there is a little silver in a ferruginous and lime matrix that forms a part of this dyke. I found it, however, difficult to ascertain this, and if there is any silver or other minerals than iron it must be in trifling quantity. The dyke runs in a northeast by north direction, and is traced for several miles.

MEDINA COUNTY.

Passing southward into Medina County we find a transition from the Cretaceous formation of Edwards and Bandera to the Tertiary (so-called). The southern part of this county presents everywhere on the surface, and sub-stratum where exposed, the sands, clays, gravels, and sandstone flags that characterize the later formations. I was very desirous to ascertain the proximate contact of the two formations with the order of superposition of the lower or Eocene strata, but the weather prevented all field work. On the Medina River north of Castroville, the county seat, I think a section or sections may be obtained determining the stratigraphy of the latter formation. In the southern part of Medina we come upon the boundary of a large area, consisting of a series of shallow depressions or basins, evidently of lacustrine origin, in which the lignites of that section abound.

Lignites.—This area embraces all of Atascosa County, the western part of Bexar, and the northern portion of Frio County. It extends west and southwest also to the Rio Grande. In going down upon these deposits or beds of lignite we find that they thin out and again recur in certain definite areas of depression, generally more or less circular in form Near Lytle we have the best development of the lignite of the county in a mine which has been opened on the lands of Mr. John T. Lytle, a short distance from the International Railroad. The top of the seam is reached by a shaft sixty feet deep. A section downwards of the superincumbent strata consists of three feet ferruginous sand, fifty-three feet clay, the lower part of which assumes a jointed form, and the roof is sandstone. The coal bed is five feet thick, sometimes increasing a few inches, and lies nearly horizontal on a bed of fire clay twelve

inches thick. The quality of the lignite is fairly good, but is occasionally mixed with thin bands of shale containing iron pyrites. Notwithstanding these defects, which only occasionally occur, the coal is readily saleable in San Antonio, and as the wood supply is curtailed, the demand will shortly be very considerable. The coal is sold at $3 per ton, and even at that price is said to yield a good profit. As the Indian Nation coal can not be sold here less than $8 per ton, I think in the near future a large and remunerative industry in this coal must result. There is a siliceous iron ore in the district, which forms a thin band generally under the sand, but I do not think it can be made available for iron smelting.

Flagstone.—A brown siliceous flagstone abounds in this country, and would make admirable sidewalk pavement. Lying in beds 4 to 6 inches thick, it could be gotten out at little expense and in any desired size. Some of this stone has been used in San Antonio, and it will grow in demand, as I think it will be more durable than the cements at present in use for that purpose.

Fire Clay.—The fire clay has been tested in brickmaking and has been found to answer for furnace and chimney work. Vague rumors of the occurrence of silver in the western part of this county have reached me from time to time, but on investigation I found it consisted of small nodules of iron pyrites.

No gypsum nor asphaltum, so far as I could discover or hear of, occur, or at least have been discovered in the county. Here, as elsewhere where the recent Tertiary is exposed, the country topographically is exceedingly featureless; the streams flow on sluggishly, and at intervals dissappear under the loose aggregations of sand and gravel through and over which they pass.

The soil is a sandy loam with substratum of clay, and produces fine crops even in dry seasons, retaining the moisture longer than the black lands. The wood is mesquite interspersed with stunted oak (blackjack).

ATASCOSA COUNTY.

In Atascosa County near Somerset we have two lignite mines that have been in operation several years. The Kirkwood Mine, which is reached by a tap road from the International Railroad, about 18 miles southwest of San Antonio, was first discovered in a well on the Harrison place, and was subsequently opened out and operated by Mr. Kirkwood, a mining engineer from Scotland. The roof is a friable sandstone, and the coal is 5 feet 3 to 6 inches thick, and has met with much acceptance in San Antonio as a fuel. The chief objection to the lignite is the liability to disintegrate in handling, which makes the coal small and unsuited to burn in an ordinary grate or stove. Close set fire-bars have been in many cases adopted, which obviates the objection, and in others respects it is a good and cheap fuel.

The Kinny Mine, which is on the adjoining property, is in all respects the same as the Kirkwood, and need not be described. It is safe to say that dozens of mines could be opened in this county if necessary. In well digging at a number of points the coal is struck at more or less depth from the surface, and doubtless as the demand increases shafts will be sunk, especially near the International and Southern Pacific Railroads, both of which pass through that section.

Petroleum.—In some of the wells unmistakable evidence of petroleum existing below is found. The smell is sometimes so strong in digging wells that they can not be proceeded with, and thin films of oil are found floating on the surface of others. No one in this county has bored for oil so far as I am aware, but I think a boring of a few hundred feet where these signs are most apparent might show some important results in that direction. As bearing on this point, Mr. George Duling, when boring for water on his place at a depth of 300 feet, struck petroleum, and subsequently in another boring 270 feet at some distance from the first, also came upon it. The flow only affords about twenty gallons per day, but it is regular and continuous, and I think would indicate a natural reservoir of some volume. This is in Bexar County, where also a shaft has penetrated two beds of coal, the upper thirty-nine inches, the lower sixty-two inches, with a jointed clay bed fifteen feet thick between them. Both rest on fire clay, the lower of which is twenty-four inches thick. Nowhere else in that section, either in wells or shafts, so far as I have heard, has this dual strata occurred. It is on the land of a Mr. Robbins, near the Atascosa line, about sixteen miles from San Antonio, and close to the International Railroad. The Atascosa, San Miguel, and Elm creeks are the principal streams of the county, but all of them go dry frequently in the summer season. The tenacity and uniformity of its clay substratum compensates for this, and fine crops of vegetables and cereals are made here when some of the neighboring counties are suffering from drouth. The county is well wooded, and the pasture is also good. I am of the opinion that this county has an important future before it in its lignites, clays, and sandstones, and, probably, petroleum and asphaltum. Two important railroads passing through or near the county, and its proximity to San Antonio, will lead to the development of its minerals, and at the same time be a market for them.

BEXAR COUNTY.

Although Bexar County does not lie within the area prescribed by my instructions, yet as it is contiguous and has been developed more than its neighboring counties, I will note a few particulars in that county of economic interest.

Brick Clays.—The clays that lie along the Calaveras Creek have been found well adapted for brick, tile, and pottery. We have now extensive brick works in the Taylor, McKay, Wilson, and Mitchell brick fields, which turn out a large and increasing quantity of excellent bricks at about eight to ten dollars per thousand delivered in San Antonio. A tile and pottery works has also recently been begun, which bids fair to increase and satisfy the demand of this section. As an illustration of the value of these developments, it may be noted that the importation of brick has ceased here, and the price has gone down from $20 per thousand to $8 in the past two years.

Hydraulic Cement.—A large bed of hydraulic cement was also discovered about three or four years ago at the head of the San Antonio River, which is now being extensively worked by the Alamo Cement Company of this city. As an illustration of its tensile strength, it stands a strain of 350 pounds to the square inch, and a crushing strain of ten times that force.

Artesian Wells.—Two artesian wells so far have been bored in this county, viz., that of General Russ, about three miles from town, and Mr. Kampman, a few miles from San Antonio; both are of mineral waters. The undernoted analysis is furnished by Professor Langenbeck, of Cincinnati, of General Russ' well:

Silica	1.34
Alumina and Iron	1.14
Carbonate of Lime	12.64
Carbonate of Magnesia	5.35
Carbonate of Soda	1.56
Sulphate of Soda	2.40
Nitrate of Soda	1.41
Chloride of Sodium	4.08
Free Carbonic Acid	16.08
Total grains per gallon of the water	45.00

FRIO COUNTY.

Proceding southward to Frio County, I note that its topography and surface indications are very similar to those observed in Medina and Atascosa.

Lignite.—In boring wells, lignite has been discovered, but in thiner seams and more mixed with impurities, iron, clay, etc. The average thickness of such seams is not quite two feet, and would scarcely be worth working, especially near larger beds. The places of discovery are the Echol's property, six miles northeast of Pearsall; on San Miguel Creek, nine miles south of the International Railroad; and on the land of Applewhite & Beaver, on the bank of the Frio River.

Pipe Clay.—On the banks of the Frio about 8 miles from Pearsall a bed of excellent pipe clay interstratified with yellow and red clay is exposed.

Soapstone.—Near Cevilla Creek on the property of T. J. Cavender, an impure soapstone containing iron and sand was discovered in digging a well.

Brine Well.—On the same property a strong brine made its appearance at 18 feet down on boring for water; this no doubt indicates a saline deposit at that point, but no further investigation has taken place.

Mineral Waters.—It is a matter of remark in that section that almost every boring or digging for water discloses mineral waters, either sulphur, chalybeate, or alum, separate or in combination, and the same remark seems to apply to the waters of La Salle, which especially to a stranger are very noticeable and the reverse of agreeable.

LA SALLE COUNTY.

La Salle County, which I next visited, is in general appearance, soil, timber, grasses, and water-courses, almost a counterpart of Frio.

On the McKee Ranch 12 miles west of Cotulla, an excellent bed of steatite, upwards of 2 feet thick, was discovered in boring a well at a depth of 75 feet from the surface, also in same well a fine white sand bed made its appearance.

Brine Well.—On the property of Oppenheimer and Cassin, 25 miles southwest of Cotulla, a strong brine was found, 20 feet from the surface, in digging a well. Both of these indications in Frio and La Salle and at nearly the same depth may indicate an extensive saline deposit in that region.

Artesian Well.—At Cotulla, the county seat, an artesian well has been bored to a depth of 1008 feet. It jets above the surface about six feet, and is of medicinal properties, and the people there claim it is equal in curative results to the far famed Carlsbad waters of Germany. An analysis has been made of this water by Professor G. Bade, of Milwaukee, Wis., which is as follows:

Chloride of Sodium	70.5217
Sulphate of Potassa	24.8391
Sulphate of Soda	55.4048
Bicarbonate of Soda	52.6437
Bicarbonate of Lime	5.7037
Bicarbonate of Magnesia	3.4047
Bicarbonate of Protoxide of Iron	0.0072
Alumina	0.1053
Silica	0.9068
Grains to Gallon	213.6000

Professor Bade says of it:

"This water is a mineral water, and belongs to that class known as alkaline saline purgative waters, of which the famous Carlsbad Water is one of the best known. It is a warm spring, having a temperature of 86° Fahrenheit on reaching the air, and being similar to the Carlsbad water in this respect its medicinal properties will be the same."

In concluding this report, partial and imperfect as it must necessarily be from the shortness of time, and still more, the continued wet weather, I think the facts gathered show sufficiently that there are mineral deposits in these counties which, even now in part, and much more in the near future, will develop into wealth producing industries.

I was gratified to find in every district I visited intelligent citizens who took an interest in mineral investigation, and who would be willing to assist in the work. This is a very hopeful fact for the future of the survey, which, as you justly state in your circular, will require the co-operation of the citizens of the state to make it effective.

I am, dear sir, yours respectfully,

J. L. TAIT.

EAGLE PASS, TEXAS, December 10, 1888.

Mr. E. T. Dumble, State Geologist, Austin, Texas:

DEAR SIR—In accordance with your instructions, I have made a preliminary survey of a portion of the territory assigned me to work in. But in making the examinations where such wide areas were to be examined in so short a time, compelling me to travel twenty-five or thirty miles per day, it was impossible to trace out all the localities of rocks, ores, coal, and other minerals, and to determine definitely their boundaries or to estimate the exact amount of territory occupied by each of them. I have endeavored as much as possible to follow geological boundaries rather than political ones, and have thus been enabled to form a better idea of geological formations of the districts than I could have done otherwise. By this means I have been able to locate both the geological and geographical positions of the ores, coal, and other useful minerals. I have measured the thickness and observed the dip and superposition of the strata, and collected specimens of useful rocks, ores, coal, etc., and have endeavored to be as explicit as the hasty manner in which the work has been done will permit, and to state the facts observed plainly and make as accurate deductions as possible therefrom.

On the 8th of November I commenced active operations in the field, beginning my work at the mouths of Pecos and of Devils rivers, and following the line of the Galveston, Harrisburg, and San Antonio Railroad as far as Uvalde; then I returned to Eagle Pass and resumed work by going down the right bank of the Nueces River as far as Encinal County; thence across the country to Laredo; thence up the Rio Grande to San Lorenzo Creek to a point northeast from Eagle Pass, and from there to this place. I will here give a general outline of the coal fields and mineral districts and describe them more minutely in describing the counties in which they occur and give the probable areas occupied by them. Fourteen miles southwest of Uvalde, on the line between Uvalde and Zavala counties, there is an outcrop of coal in the north bank of the Nueces River. At this place the stratum is four feet ten inches thick, with a three-inch division of slate in the center. The rocks from this place to Laredo represent a monoclinal dip, and the western boundary of this coal field can be represented by a line drawn from this point on the Nueces River to a point four or five miles east of Carrizo Springs; thence southward across the headwaters of the Moro

Creek to the hills upon the eastern banks of the San Lorenzo Creek; following this geological boundary to the Rio Grande, thence along this stream to a creek ten miles east of San Tomas, called San Civeale, where it becomes thinner and disappears beneath the surface. This outlines the western and the southern boundaries of this coal field in Texas. The northern boundary I had not time to locate; but allowing that it extends no further north than the Nueces River, where it is seen exposed in several places, we have outlined an area of country embracing 2700 square miles. I have sent you ten or twelve samples from different localities, and I examined and measured the outcrop at many other localities from which I did not take samples. In addition to this coal field, there is at Eagle Pass, which is forty miles southwest from the outcrop on the Nueces River, another coal stratum four feet six inches thick that has an outcrop along the Texas and Mexican sides of the Rio Grande for ten miles. The abrupt inclination of the stratum here soon carries it to a depth of from 400 to 600 feet below the surface, so that its eastern or southern boundary can not be determined by surface indications; but allowing that it does not extend further east than the San Lorenzo Creek, which is a reasonable deduction, it then increases the area of the coal field just outlined to something more than 3700 square miles. I measured the coal strata at three places in the Hartz mines at Eagle Pass. This is the only place where the coal is worked. At one place there was four feet six inches of good coal without any divisions of slate; at another place it was five feet four inches, with three divisions of slate aggregating five inches, leaving four feet eleven inches of coal; at the third place the strata was seven feet three inches thick, with five divisions of slate aggregating fourteen inches. This gives a coal stratum with an average thickness of over five feet. This is a good commercial article, and appears to be very firm, hard coal. These two coal strata represent the extent of the coal fields of Southwest Texas. Although there are at different places in this field three strata of workable coal and where one overlays the others, there will be an aggregate thickness of ten feet of coal. The stratigraphical position of the Eagle Pass coal is 600 or 700 feet below the Nueces and San Tomas coal strata. In addition to this, there are said to be iron, lead, and silver deposits in the northern part of Uvalde County and asphaltum in Kinney County, but I did not have time to examine them. As far as known these constitute the mineral resources of the district. There are 1,000,000 tons of coal for each foot per square mile, and a calculation made upon this basis will give us 3,000,000 tons per square mile, and if we allow that one-half of this area will be non-productive or too thin to be perfectly worked, we still have enough to supply all possible demands for hundreds of years. In fact the supply is practically inexhaustible. The agricultural resources of this part of the state have not been developed, although the greater portion of it is susceptible of a high state of cultivation. The soil is of an excellent quality and will produce almost any kind of a crop if supplied with water. There are a few districts where some farming has been done by irrigation, and these enterprises have been very satisfactory to those engaged in them, as at Del Rio, in Val Verde County, and some small districts in Kinney County. The arid condition of this part of the state renders farming very unsatisfactory without an artificial supply of water; but while nature has withheld from us the needed rainfall, she has been lavish in her provisions for our necessities, and we only need the finger of science to point to her rich provisions for our needs and bring to light the hidden resources that are within our reach. A line drawn from a point on the Nueces River south of the town of Uvalde to a point ten miles west of Carrizo Springs, thence south to the Rio Grande, will represent the outcrop of a *sand bed* nearly 200 feet thick. This sandstone has a monoclinal dip to the southeast. It is a very loose, coarse, friable sand, and free from any deleterious salts, and is an inexhaustible reservoir capable of furnishing water sufficient for irrigating purposes. This sand stratum supplies the numerous wells at Carrizo Springs, and an example of its capacity may be seen at the ranch of Mr. Fayette Vivian, ten miles north of Carrizo. This well is 175 feet deep and produces a stream of excellent water four inches in diameter. This sand lays conformably upon the rocks of late Cretaceous, and will be found at Laredo at a depth of about 500 feet. At this place all water obtained above this sand will be so strongly impregnated with mineral salts as to be unfit for use. This mineral water can be shut off, however, and the pure water from the Carrizo sandstone obtained. In the northwestern part of Zavala, the western part of Uvalde, and the northern parts of Maverick, Kinney, and Val Verde counties we can never hope to obtain artesian water for agricultural purposes, but water may be obtained for domestic purposes by boring and pumping to the surface. These localities are so near the apex of an anticlinal ridge that we can never hope to obtain artesian water in them. and the only prospect of obtaining water for agricultural purposes in this locality is to bring it from the Rio Grande and the Devils rivers. A dam can be constructed across the Rio Grande a few miles above the mouth of Devils River, and the water from the river turned into a canal and flumed across Devils River, which would supply the needs of the locality. At the point named the banks of the river are almost vertical to a height of nearly 150 feet, and a dam 400 yards long would reach to the opposite bank. This dam would have to be built to a height of 120 feet to

raise the water sufficiently to carry it across the country to Spofford Junction. There is something like 1,000,000 acres of excellent land in this vicinity that could thus be supplied with water. Should this supply be inadequate, a dam could be constructed across the rocky canon of Devils River and a reservoir so constructed that the water from this stream could also be used. The only objection that could be urged against this scheme would be the cost of the dam and the possibility of Mexican interference, both of which could be easily and amicably arranged. The lands of this locality are now valued at $1.50 per acre, and by adding to the value of these lands $2 per acre we have a capital sufficient to build the dam and construct the canal. This will provide homes for thousands of people where the cry of drouth-stricken sufferers will not be heard. The advantages to be derived from such an improvement are too numerous to be mentioned, but one of the principal benefits that might escape the attention of the economist is the fact that where large surfaces of the soil are ploughed and broken up they absorb the water from the rainfall and prevent the overflow of streams, and by gradual evaporation produce a more humid atmosphere which will increase the rainfall and add materially to the value of grazing lands in the vicinity of such cultivated districts.

For a more minute description of this territory, I will refer to each subject under the heading of the counties.

VAL VERDE COUNTY.

Val Verde County comprises within its limits the rocks of the sub-Carboniferous, the lower and middle Cretaceous. It contains no coal, iron, or other metals of commercial value, and aside from the amount of land that could be irrigated, it is principally a grazing district. There are about 3000 acres of land in cultivation in this county. The products are corn, oats, sugar cane, fruits, and vegetables. It is well adapted to the raising of grapes, pears, prunes, peaches, and in fact nearly all kinds of fruits found in the temperate zone except the apple. The farming carried on at Del Rio is but a small example of what can be accomplished all along the Rio Grande by irrigation. The first rocks examined in this county were at the mouths of the Pecos and Devils rivers (represented by Specimen No. 1), a massive, dark gray limestone, containing but few fossils, and beds of cherty lime and flint. It has been very much disturbed, the cracks running nearly northeast to southwest, and contains calcareous spar in many places. In some localities the series shows a tendency to disintegrate, and at places it forms caverns, as at Painted Cave and numerous other places along the Rio Grande. The surface of the country immediately underlaid by this formation is full of depressions or sink holes. Where the surface water disappears in some localities the strata contain seams or joints, resembling sutro joints. No. 2 is evidently the base of the Cretaceous formation. It is a rotten or chalky limestone, about eighty feet thick, containing iron concretions, usually crystallized in cubes, and where not exposed to the elements are sulphuret of iron. There are also nodular and reniform concretions that. when broken, present dendritic forms of crystallization. These rocks contain many fossils, usually encrusted with oxide of iron. This stone upon exposure crumbles into angular particles, usually of about two pounds weight. The fossils of this formation are represented by specimens sent in—locality, west of Del Rio to Devils River, and forming buttes along the Pecos River. No. 3 forms small buttes below the town of Del Rio, and along Devils River, and is composed of ten feet of whitish yellow argillaceous shale, fifty feet of greenish, yellow shale, forty feet of red and purple shale, interstratified with this stratum of limestone and siliceous limestone discolored on the outside by oxide of iron. The fossils of this series are forwarded with this report. The formation forms many buttes running parallel with the Pecos and Devils rivers. Eighty feet of rotten limestone overlaying No. 3 occurs three miles east of Del Rio. It has a monoclinal dip with an inclination of twenty feet per mile, and soon disappears. The fossils of this series also accompany this report. No. 5 represents a stratum of limestone interstratified at many places with bituminous shale, and the limestone itself appears to be impregnated with bitumen, and if heated will give off gaseous fumes and flames. This stratum of limestone ranges in thickness from one-half to six inches. The thicker strata will make very good building material. The International Hotel, Piedras Negras, Mexico, is built of stone belonging to this series of rocks. This limestone stratum breaks with a smooth even fracture. This series of rocks is about 125 feet thick.

KINNEY COUNTY.

This county is located upon the line of the middle Cretaceous rocks, and like Val Verde, at no place we visited is there any possibility of obtaining coal or other minerals in paying quantities, but as a grazing county it is unsurpassed. It is watered by the Pinto, Madona, and Las Moras creeks, and upon each of these there is a limited amount of farming done by irrigation. The soil of this county is a rich black loam, unsurpassed in fertility, and only

needs the aid of capital to bring the waters of the Pecos, the Rio Grande, and the Devil's rivers upon it.

On the banks of the Pinto and the Las Moras creeks there is an exposure of excellent building stone, and this is evidently the equivalent of the white limestone used at Austin and San Antonio.

This county contains one extinct volcano, and perhaps others that I did not have time to see. This extinct volcano is about twelve miles northwest of Fort Clark, and is similar in appearance to those described in Uvalde County.

UVALDE COUNTY.

The general inclination of the rocks in Uvalde County represents a monoclinal dip to the southeast, although there are undulations that give rise to local anticlinals and to synclinals. The northwestern part of the county is represented by a series of rocks (see Specimen No. 1), like those at the mouth of the Pecos; and where metamorphic action has taken place there is a strong probability that useful minerals will be found, but I did not have time to examine it for these. I have heard of the existence of iron, silver, lead, and kaolin in this portion of the county. Southeast of the above mentioned rocks there is an exposure of the lower and the middle Cretaceous, and fourteen miles southwest of Uvalde I found the upper or late Cretaceous, and perhaps an equivalent of the Laramie Peak formation, which however is not yet definitely determined in this series of rocks. At this place I found the northwestern exposure of the Nueces or San Tomas coal fields. I measured the outcrop in the edge of the water of the Nueces River, and found it to be four feet thick, with a two and one-half inch division of shale in the center. I was informed by Mr. Gillespie, upon whose land the outcrop occurs, that he had sunk a shaft into the coal, and found it to be an excellent quality, and to be four feet ten inches thick, with a two inch division in the center. This is the same coal that is being worked at San Tomas, but its area in Uvalde County is very limited and will only be found near the county line joining Zavala. No. 7 is a sample of this surface coal. Above this coal is a stratum of four feet of argillaceous shale; then three feet of ferruginous sandstone. Below the coal there are eight inches of fire clay, fourteen feet of yellow and gray sandstone of a soft friable character; then several feet of shale, under which there is a bed of oyster shells which has a thickness of twelve feet. No. 18 is a sample of these oyster shells. This oyster bed is underlaid by eight feet of black asphaltum sandstone, from which in warm weather the asphaltum exudes and forms small pools. It is probable that where these sands are covered to a depth, where evaporation does not take place, this sand will produce a considerable quantity of the heavier class of petroleum, such as lubricating oils. This can only be determined by drilling. Several feet below this is a ferruginous and siliceous shale containing fossils. No. 8 is an example. These are the lowest strata examined along the Nueces River. At the crossing of the San Antonio wagon road to Uvalde on the Frio River there is a trap dyke, 400 feet wide, filled with a greenish black dolerite of a heavy, compact variety, that will perhaps answer the purpose for making paving stones, if not too much divided by cracks. This dyke has produced some very curious conditions. The shale and limestone for a considerable distance have been uplifted and metamorphosed, and when in direct contact with the igneous rocks the original lines of stratification have been obliterated, and they present the appearance of a chloritic schist. (See Samples Nos. 12, 13, and 14.) This schist has small particles of limestone imbedded in it that have the appearance of having been dropped into it while it was in a liquid state; but by a careful examination at a little distance from the igneous rock, the original lines of stratification can be traced back until we find it in its original condition, where they prove to have been limestone and shale. Ten miles west of Uvalde is another extinct volcano. The lava or trachyte is of a blackish brown color, similar to that of the dyke just described. The igneous rocks here are not so much divided by cracks as in the dyke. But few crystals can be found, and they are only seen along the contact of the igneous rock and the limestone. (See Sample No. 15.) Sample No. 12 is a metamorphic rock from this vicinity. There are a number of these volcanic cones in the vicinity, presenting the appearance of buttes. These lands and their general appearance indicate that they are of a much more recent date than the basaltic and porphyritic ranges of the Chinati Mountains. I have observed one of these cones on the Mexican side of the Rio Grande of a very similar appearance to those near Uvalde, where the lava overlaid the gravel of the drift formation, showing it to be of very recent date; but there is nothing but the general appearance and character of the lava to indicate that they are of same date. At the town of Uvalde I found a synclinal valley, resulting from an uplift by the trap dyke and the volcanic cone west of the town. This synclinal basin has been partly filled by the debris of the drift period, and subsequently filled to a level with the surrounding country by the bluff formation, thus presenting to the eye a level plain. This provision of nature

is of the utmost importance from the fact that this gravel deposit affords an immense reservoir for water, and wells sunk into this to a depth of forty or fifty feet afford an inexhaustible supply. This water has to be pumped to the surface, and it is hardly probable that at this place artesian water could be obtained except at a very considerable depth.

ZAVALA COUNTY.

A line drawn from the point where the Zavala and Uvalde county line crosses the Nueces River, to the south line of the Francisco Perera survey, will represent the western limit of the Nueces coal field in this county, thus leaving about two-thirds of this county in the bounds of the coal field. The rocks in this county represent a monoclinal dip to the southeast from a few miles west of the western limit of the coal field to the eastward. An abundance of artesian water can be obtained by boring into the red sandstone series of rocks underlying the coal series about 150 feet. This sandstone will be from ninety to 150 feet thick in this county, and will afford an abundance of excellent artesian water. There are no minerals in this county except this coal stratum and a thin stratum of clay iron stone of little or no value.

WEBB COUNTY.

All of the western half of this county is in the limits of the Nueces coal fields. There are three strata represented in a part of the county, but the middle is the only one of any economical value. This stratum ranges from eighteen to thirty-three inches in thickness, and has a two-inch division of slate in the centre. This coal does not belong to any of the other classes of coal found in the United States, that is, so far as I know. It is a very firm, solid coal, and breaks with a glossy, conchoidal fracture, and is not easily pulverized. It is very clean and free from dust, and has the appearance of hardened asphaltum. It contains but few plant impressions, is remarkably free from sulphide of iron, burns with a vigorous bright flame and oily appearance, contains a considerable quantity of ash, but will not make clinkers if separated from the slate in the centre of the stratum. It has some of the characteristics, but not the slaty fracture, of cannel coal. It has been unwittingly called lignite by some, but it has none of the characteristic features of lignite, and is much superior to it in quality. No. 21 is a sample of the coal. This ought to be a good gas coal, and for use in stoves and grates it is superior to the common variety of the bituminous. It will answer very well for making steam where the ash boxes are properly constructed, and will make an excellent fuel for use in reverberatory smelting furnaces, but has not enough fixed carbon to be used in a blast furnace or for blacksmith work. The last exposure of this that I found in the direction of Laredo was at San Civiale Creek, ten miles east of San Tomas. It is exposed and worked at San Tomas, the capacity of the mines being about eight carloads per day. No. 22 is a surface sample from an outcrop about eight miles west of San Tomas at a creek called Espado. At this place there are three strata of coal. The first one is twelve inches thick. No. 24 is a specimen. Below this there are four feet of shale, and then the San Tomas strata of coal, which is thirty-four inches thick at this place with a two-inch division. (See sample No 23.) Below this there are thirty feet of shale, then twelve inches of coal from twelve inches to fourteen inches thick. (Sample No. 25.) At Llava I found a bituminous sandstone resembling somewhat the asphaltum sand at Uvalde, except that instead of the bitumen being a semi-lignite state, it resembles the San Tomas coal. (See sample No. 31). This sandstone occurs at nearly every locality where its stratigraphical position was exposed. It is thirty feet below the coal stratum, and occupies the stratigraphical position of the Uvalde asphaltum sand. Twenty five miles northwest of San Tomas, it is two feet thick on a ranche belonging to Mr. Brune. At this ranche the coal stratum is thirty-four inches thick with a three-inch division. (See sample of coal from this place, No. 28.) No. 35 is a sandstone encrusted with salts of magnesia. No. 34 is a sandstone with plant impressions from beneath the coal strata. No. 36 is a sample of river valley soil from Webb County. No. 37, upland soil from Webb County. No. 28 is a sample of sand twenty feet below the coal. No. 39 is the only stone found in Webb County containing fossils. No. 41, fossil plants, Laredo. No. 42, magnesia near San Tomas. At a place thirty-five miles north of San Tomas, there is an exposure of shale containing crystallized concretions of gypsum in considerable quantities. (See samples No. 45.) No. 44 is from San Tomas coal mines.

DIMMIT COUNTY.

The west line of this county will pass near the western limit of the Carrizo sandstone. The top stratum of this sandstone has about 40 feet of red sand, which gives its characteristic color to the soils where it is exposed. The base of this series of rocks is composed of gray and brown sand, and some of the more indurated strata will answer for building stone. The court house at Carrizo is built of this stone, and it is the source from which the wells of

Carrizo are supplied with water, and at any part of this county east of the outcrop of this stone there will be no difficulty in obtaining artesian water. This sandstone in this county is about 200 feet thick, and at the eastern line of the county it will be found at a considerable depth below the surface. 35 feet above are strata containing clay ironstone of little or no economical value. A line drawn from the south line of Zavala County near the Francisco Perera Survey to a point a few miles east of Carrizo to the headwaters of the Moro Creek, thence across the dividing ridge to San Lorenzo Creek, will represent the western boundary of the Nueces coal field in this county. The soils of this county are variable in character, and each series of rocks represented exerts an influence upon the nature and character of its soils. There is perhaps, therefore, a greater diversity of soils in this county than any other in the state.

MAVERICK COUNTY.

Maverick County represents within its borders the middle and late Cretaceous rocks. The northern and western parts of the county have a rich, black soil upon the uplands. This soil has resulted from vegetable mold and the disintegration of the limestones of the middle Cretaceous rocks; its fertility is unsurpassed, and if supplied with water would be the garden of southwest Texas. The southern and eastern parts have a more sandy and argillaceous soil, resulting from the disintegration of the sandstones and shales of the coal series of rocks.

The soils in the valleys have a considerable depth and great fertility, and when supplied with water will produce excellent crops. The construction of a canal and ditches are now under contract and construction will commence in a few days. By enterprises of this character southwest Texas can be made a rich agricultural country.

Five miles northwest of Eagle Pass there is an outcrop of coal that averages something over five feet in thickness. There is an exposure of this coal stratum for a distance of ten miles in Texas and Mexico, and a large bend in the river gives Texas the benefit of most of it. From the Hartz mines, where it is extensively worked, the line of the outcrop drops east to the Olmos Creek, then follows the valley and eastern banks of this stream several miles, and then drops back to a line running east northeast toward the Dimmit County line. These strata represent a monoclinal dip to the southeast with an inclination of twenty feet per mile, so that it is impossible to determine by surface indications the extent of territory represented within this coal field, but the surface indications and the outcrop prove the existence of not less than 120 square miles in this county, and its geological horizon will be found over two-thirds of the county, dipping beneath the Nueces coal at a depth of 600 or 700 feet. It is no unreasonable deduction to say that it will be found beneath the Nueces coal. This represents the mineral resources of this county except three strata of clay iron stone in the shales above the coal. At some places these strata are twelve inches thick, with an aggregate thickness of three feet. If properly prepared they would make an excellent mineral paint. See sample labeled iron, from Maverick County.

Near the town of Eagle Pass there is an abundance of excellent material for the manufacture of a superior quality of brick. The clays are remarkably free from iron, and the bricks burn to a beautiful cream color that gives a very pleasing effect to buildings constructed of them. There are several sandstone strata in this county, and some of them will make very good building material. Some of them resemble chloritic sands. (See sample No. 46). There is an abundance of limestone of an excellent quality for building purposes in this county. It is equivalent of the white stone used for building in Austin and San Antonio. Twenty miles east of Eagle Pass there is an extensive deposit of yellow earth somewhat resembling clay. If mixed with water and burned it gives the odor and taste of burned gunpowder. It will not crack while in the fire by suddenly heating it, nor break by being suddenly cooled. I believe that an analysis will reveal the presence of a compound not commonly found in Texas soils.

Respectfully,

J. OWEN.

ECONOMIC MINERALS OF SAN SABA COUNTY.

Three and a half miles southwest of the town of San Saba there is an outcropping of an extensive deposit of colored marble of great beauty. The greater part of these San Saba marbles are true marbles, having a crystalline texture and a saccharoidal fracture. There is unmistakable evidence of the existence of laccolites or subterranean eruptions of molten matter from the depths below. The heat from this incandescent matter, which in these cases is injected

through dykes to within a few hundred feet of the surface, has metamorphosed the limestone beds converting them into true marble. It has been proven by actual experiment that a block of common limestone may be converted into beautiful statuary marble by means of heat and moisture under great pressure. These powerful agents are capable of effecting remarkable changes in color and texture. All fossils becoming completely obliterated and the color changed to pure white unless iron or some other metallic coloring matter is present in the limestone.

There are many varieties of this marble, all of which are handsome. The greater part are colored with rich warm tints clouded and veined. One kind has a solid delicate flush of peach bloom without cloudings or veins. Another and the most abundant has a fine rich yellowish ground clouded and veined with warm colors, pink orange, and red. Another has a light flesh colored ground with beautiful cloudings of light red.

South of this deposit some ten miles there is an extensive deposit of white marble only partially crystalline in texture. It closely resembles ivory in color, and readily takes a fine polish. This is stratified, the layers having a thickness of from a few inches to two feet. It can be easily and economically quarried, will weather well, and will be valuable for most purposes for which white marble is suited. The colored marble occurs in massive beds some from eight to twelve feet in thickness. It can be quarried in immense blocks.

Specimens of these marbles were furnished the National Museum at Washington, and were pronounced very beautiful, and in composition unusually interesting, by Dr. Hawes, who was then curator in charge of the petrological department, and probably at that time the highest authority upon rock material in the United States. He said that they were different in composition from any other specimens in the extensive collection under his charge. Subsequently these specimens formed a part of a limited number of blocks selected from the vast collection of the National Museum to represent the different varieties of marbles of value found in the United States at the World's Fair at New Orleans. The San Saba marbles were given a prominent place in this Government exhibit.

In the mineralogical and geological department of the Texas exhibit at New Orleans, polished blocks of these beautiful marbles formed an attractive feature. They now occupy a place in the museum of the Texas State Geological and Scientific Society, at Houston, Texas.

Col. H. P. Brewster, formerly Commissioner of Insurance, Statistics, and History, who was commissioned to select the material for the inscribed block from Texas for the Washington Monument, after carefully examining rock material from all parts of the state, selected the San Saba marble as best suited for the purpose. An insufficient appropriation and want of facilities for quarrying and transportation defeated his purpose to use it.

Want of facilities of the same nature also prevented its use in place of the Georgia marbles used in our State Capitol.

Within less than a half mile from the outcropping of the principal marble bed there bursts out from the bluff one of the great springs of San Saba County. The marble is so situated that it can be placed upon trucks immediately from its beds and run directly under the saws propelled by the water power afforded by the flowing spring. Within the limits of San Saba County there are no less than eighteen large springs, which are constant. They are artesian in nature and have their origin in mountain regions, many hundred miles to the northwest, where melting snows and abundant rains keep up a constant supply of water. This volume of water is not at all affected by the rains which may fall within many hundreds of miles of the outflow. These great springs are utilized for purposes of irrigation, and they afford also motive power for machinery. They occur around the border of the outcroppings of the Paleozoic formation, which occurs within the southern borders of the county.

Sandstone suitable for building purposes occurs in very great abundance in many parts of the county. This valuable sandstone is exceptional in several respects. It is admirably adapted for the construction of that class of buildings where beauty in color and ornamentation must be combined with economy in cost. In color, nature has made it as near perfect as the experienced artist could desire. Uniformity of color in this rich and abundant material is truly astonishing, as blocks taken from beds miles apart have been found to match in color perfectly. The color is a rich warm yellow, that tint most desirable for large as well as more humble structures. Under the chisel it works easily, especially when fresh from the quarry. Time and exposure to the air hardens it to a considerable extent, and weather stains are not found to mar its brightness of color. The Colorado River cuts its way through an extensive deposit of this valuable sandstone, exposing many strata, some of which are fully twelve feet in thickness. Blocks of any desired size can be quarried at little cost for shipping, etc.

Grindstone grit of a good quality has been found on the San Saba River near its mouth, and in several other localities on the Colorado River. That near the mouth of the San Saba was worked many years ago, and grindstones from it are now in use by many families in the county.

Near the town of San Saba there occurs a deposit of a blue limestone of superior quality, it

is compact, works admirably under the chisel, takes a fine polish, and when well polished it is very handsome. The process of polishing darkens the color to a bluish black. It is admirably suited for trimmings, forming a fine contrast with the bright colors of the sandstone and marbles found in the vicinity.

Fire-proof rock is found in great abundance, underlying the above mentioned blue limestone. This material, though rough and hard to work, is valuable for lining to furnaces, fire places, etc.

White compact limestone or Texas marble occurs in great abundance from the San Saba River to within a few miles of the outcropping of the Paleozoic rocks in the southern part of the county. This material is too well known to require description It is impracticable for any use except for making lime, perhaps.

The Paleozoic rocks, granite, granitic sandstones, quartz, schists, etc., occur in the southern part of the county. Granite equal to that composing the walls of our new Capitol is found in several localities

In the western portion of the county there is an extensive deposit of very pure quartz sand, remarkably white and clean, fully equal to any found in the United States for the manufacture of glass, etc.

Iron ores of the various kinds are found in great abundance in the southern and western parts of the county. No particular value has been attached to their possession by owners of the lands in the absence of means of transportation and of the proper fuel for smelting.

In the northwestern portion of the county there is a district of undefined extent which is included in the coal field which stretches across from the Indian Territory.

Coal found at Milburn and its vicinity is said to be of superior quality to that found at Waldrip. No mining for coal has been done within the county.

The so-called mineral belt extends through the southern third of the county, and in it have been found gold, silver, copper, lead, and manganese, but none of these minerals have as yet been mined with success. Recently some ores have been procured from Wallis Creek, tested, and the lands upon which the ores were found bought at a very high price by some capitalists from Washington City. Other lands adjoining those bought were sought by the same parties, but owners refused to sell. The ore will be worked for silver.

A. GREGG, M. D.

To E. T. Dumble, State Geologist.

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